



Analysis on Food Security and Insecurity for Sustainability in India: Reference to Sustainable Development Goal

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ABSTRACT

The world shares in equal measure the issue of food security which causes an underprivileged approach to communities driving sustainable development. India has seen its green, white and (nearly) yellow revolution in agriculture, but mountains of food still go waste while poverty leads to starvation deaths by the thousands every year. In the case of developing countries, such as India are more threatened with immediate and future it is food insecurity. Possibly also that agriculture fights climate change but is not the solution to total hunger eradication. Security encompasses also the protection for our environment as well as consumers. The paper has discusses various aspect of food security and instability in the Indian context understanding Sustainable Development Goal No. 2 with initiatives taken by research organizations for poverty eradication. The end of the paper offers a suggestion on how to adapt or strengthen this public-private partnership vision and zooms in on demand-side factors: territory, physical configuration, socio-economics. Institutional reforms in the water sector, like setting up private/tradable rights to withdraw on groundwater and public reservoirs have a massive effect making farm outputs more productive.

Keywords: Agriculture, Environment, Food Security, Groundwater, Sustainable Development.



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INTRODUCTION

Inflation in India is a serious issue at current levels of food inflation. Production is barely up in some areas, while it remains stagnant for other foodstuffs. The 53rd Meeting of the National Development Council (NDC) has just adopted a resolution that seeks to enhance rice production by an extra 10 MT, wheat output by another eight million tons and pulse volume -- two MT more--by dorning their part in making these targets reality before mid-2011. The proposed National Food Security Mission (NFSM), when it is implemented, should assist the nation to meet these targets rapidly. In general food safety, and in particular to encourage entrepreneurship stable production and provision of foods must be available enough stagnant people at risk. Summary This paper seeks to question the problem of food security based on poverty and sustainability. Rising food prices in developed countries have taken its toll on consumers or other industrial workers. The government is trying to reduce the price of food. It affects the farmers yield as well as their earnings. The UN defines food security as a state in which all people, at all times have physical and economic access to enough safe and nutritious food that meets their dietary needs for an active healthy life. Such imports of food are common in India and other developing countries. One aspect of food security is the accessibility and affordability of household foods. Infrastructure must be either created, or built to defeat a food scarcity. A safer response to the problem would be storing food for an emergency or increasing worldwide food provision. The maintenance of agricultural assets including land and water help protect world food stocks. With a quarter of the world's hungry people living in India, UN-India estimates that nearly 195 million are undernourished.

Chronic under nutrition affects 43% of Indian children. In 2020, India was placed at the 71st amongst the leading large nations in terms of food security index. Even though important changes have taken place around the world, food security is still just a dream for over 800 million people in developing countries (Leisinger 1996). However even that 1.5 billion more people world wide exist since then, it is clear progress has been made with regards to food security as the number of undernourished individuals dropped from its peak in 1971 at around 890 million (FAO conducted survey cited in Leisinger et al.imwrite1996). Asia harboring nearly 73 percent of the world's less developed population, for example witnessed a decline in the number of undernourished individuals from 707 million in 1969–1971 to only but five hundred and twenty millions between 1990 – '91 (World Population Data Sheet 1996 as cited by Leisinger). More startling is that its rate of undernutrition has decreased significantly, 37 to 16 according to FAO data from, despite an average annual population growth rate of percent. In its pursuit of food security and self-sufficiency. This means we need to produce enough food on our own land in order to protect our national food security. This includes the need to generate economic growth especially as a means of increasing both poor people's incomes and purchasing power, so that this becomes more affordable; ultimately also would guarantee domestic food security. Irrespective of self sufficiency in food grain at macro level, agriculture management through fixation of FGP Prices, Consumer Pricing Regulation and PDS will have a larger play compared to securing the Food Security substantially on home (Banik 1997; Goyal 2002) Governments insulate farmers against low and unpredictable agricultural prices by interfering in a significant portion of the food market. Nonetheless, ineffective pricing often leads to negative outcomes in terms of people's poverty to food. Regrettably, the paper is unable to deal with this important dimension of the food security (Banik 1997).

REVIEW OF LITERATURE

The State of Food Security in India: Trends, Patterns, and Factors

In an article entitled "Food Security in India: Trends, Patterns and Determinants," authors Anjani Kumar, M.C.S. Bantilan, Praduman Kumar (all affiliated with the International Crops Research Institute for Semi-Arid Tropics), Sant Kumar Singh (Project Directorate on Animal Disease Monitoring & Surveillance) and Shiv Jee declared that all three dimensions of food security are related to each other based on latest availability–accessivity — absorbability situations in India. We have also results showing food management practises, and impacts on food security. The persistence of malnutrition indicates the need for measures to more sustainably increase food supplies in future, notably through protracted effort at enhancing productivity.



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A belt-tightening and simplification of the food delivery system is needed. Further research is needed to understand why PDS always does bad in certain states and fairing well some other places. The fate of the NFSA will be largely decided through how successfully PDS is implemented across India. Since it is well known that dietary intake and household income are positively related, a most obvious conclusion is to increase the provision of anti-poverty programmes for almost all across country development planner while ensuring better results. Improve the productivity of public spending and strength social safety net proposals (MNREGS, ICDS, NFSM, Mid – Day Meal, PDS etc), should be taking into account greater significance in the country's forthcoming planning exercise. If successful states are efficiently managing their PDS, the underperforming states should adopt it. So, you can go for a different PDS system in these states.

Vision 2020 for Nutrition and Food Security

Despite announcing a plethora of programmes for tackling food insecurity, there was no significant improvement in the low energy and high rates of malnutrition as indicated by R. Radhakrishna and K. Venkata Reddy [Food Security & Nutrition: Vision 2020 - An Academic document]. Global improvement in nutritional status also remains slow. He said: 'Nearly half of the population are chronically undernourished, with elderly people and mums and kids at risk in families on low incomes. Even in homes subjected to prolonged malnutrition, the share of consumption expenditure spent on food is very gradually decreasing. We should be quite concerned that 30% of those in the lowest income quintile are food insecure. Not even the middle 40% are safe from this. Auctioning food also did little to end mass hunger. Income poverty, further reduced at the current growth rate, should be substantially on its way to eradication by 2010—even though food insecurity may continue in some impoverished regions. In addition, the recent move towards more market-oriented (and global) macropolicies mean that poorer households are at risk to be a mechanism through which uncertainty in the marketplace is passed on. The consequence of this is that a range of programs has to be targeted specifically at the poor. Bringing in dietary change is a necessary condition but not a sufficient one to fight malnutrition in India. Other leading cause of malnutrition is such as gastrointestinal and respiratory infections (linked with a high prevalence), behavioural factors like incorrect feeding or weaning practises, besides insufficient food consumption. These are all contributing to the poor digestion of what you eat. Although it provides more levers of government intervention, economic growth is unlikely to have a large effect on nutrition in the near future unaided. But until we are able to feed all our citizens adequately then food initiatives must be effective and efficient.

Facts and Interpretation about Food and Nutrition in India

Jean Dreze writes in a recent paper "Food and Nutrition in India: Facts and Interpretations," referring to Angus Deaton's essay on the same topic. It tries to solve some mysteries — including a prediction of the steep reduction in average calorie consumption over the next 25 years. The fall in real per capita spending has taken place at every level of the income distribution, even though both real incomes and the relative price of food are little different from where they were 60 years ago. One hypothesis holds that the change in supposedly underserved hunger has four catalysts (less exercise, a healthier planet or fewer environmental toxins); one of these is also responsible for most allegedly under eaten calories. That being said, this does not mean that Indians are devoid of calorie deficits at all; quite to the contrary in fact. These failures are manifested in some of the worst anthropometric indices in the world and should have long been a source concern given how sluggish their performance is. Nevertheless, current trends remain ambiguous and enhanced nutritional surveillance is urgently required.

India's Food Security: Progress and Issues

The article, "Food Security in India: Performance and Issues," was written by Prof. Kalpana Singh. She stated that one of India's policies' top priorities has been the population's access to food and nutrition. The three crucial elements of food security are accessibility, absorption, and availability (nutrition). All three of these are connected. This paper's main goal is to evaluate India's performance in terms of these three aspects of food security. The average annual growth rates in food grain production yields and area under cultivation have been calculated for five time periods: before the green revolution (1950–51 to 1966–67), during the early green revolution (1967–68 to 1979–80), during the mature green revolution (1980–81 to 1989–90), during the early economic reforms (1990–91 to 1999–00), and during



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the economic reforms (2000-01 to 2011–12). India's production of food grains had decreased when it entered the era of globalization. The free market has hurt food grain production, and since the New Economic Policy (NEP) was introduced in India, the growth rate has decreased. With respect to the accessibility aspect of food security, a long-term trend in household consumption patterns indicates a decrease in per capita direct food grain intake. Furthermore, India hasn't had the best track record when it comes to food security and nutritional outcomes. The World Food Security Index 2012, released in New Delhi in September 2012, categorized India as "moderate". It ranked India 66th out of 105 nations and concluded that the biggest danger to the food security of Indians is not availability but rather price. India scored the lowest (38.4) for food access and the highest (51.3) for food availability. It also highlights how inadequately its infrastructure supports the effective distribution of food. In a similar vein, India fell to 70th place on the 2013 Food Security Index. These are paradoxical times, and the issue is not so much a scarcity of food as it is a deficient distribution system.

India's Food Security: Problems and Difficulties

The scientific essay 'Food Security in India: Problems and Challenges' by Pramod Kumar, P. Anbukkani, D.R. Singh, and Amit Kar states that while half of India's population faces severe famine and droughts, the other half struggles to put food on the table. India is the country with the greatest number of hungry people in the world, with over 200 million individuals. India's food security situation is described as "alarming" by the 2013 Global Hunger Index (GHI), which ranks 63rd out of 84 countries with a GHI of 23.90. One of India's primary worries regarding food security is the impact of such large-scale government purchases of food grains on open market pricing. Identify the primary areas for PDS reform and alternative approaches for providing eligible families with food grains and subsidies in light of the current distribution system's flaws and inefficiencies. It is a positive step toward a universal right to food that ensures that everyone has access to foodgrains subsidized by the PDS. It is also said that identifying and excluding the rich would be significantly easier than doing the same for the poor. Systems of distribution, storage, accountability, and monitoring need to be implemented to guarantee minimal leakage. Decentralized procurement needs to be made available and implemented. There is a need to improve the purchase of coarse cereals and expand the procurement net to include more states. Food coupons or entitlements linked to Aadhaar cards will eliminate the need to buy and distribute more than 500 lakh tonnes of foodgrains each year, as well as the problem of diversion.

India's Food Security: Concepts, Realities, and Innovations

A article named 'Food Security in India: Concepts, Realities & Innovations' is penned by Prof. BJ Lathi and Prof. Parag Narkhede. They stated that global economic and environmental factors are having an increasing impact on food security in general. As a result, food shortages have an impact on food prices, which can worsen humanitarian crises and lead to social and political unrest. Studying the concept of food security provided in the 1996 World Food Summit's Rome Declaration on Global Food Security is preferable in this context. So, the researchers tried to understand how a global issue was impacted by food security. The Declaration of Rome declares that "food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritional food to suit their dietary needs and food preferences for an active and healthy life." Based on similar tenets, India has implemented a range of policies aimed at ensuring food security for its populace, ranging from concerted efforts to boost agricultural output to significant market interventions designed to stabilize prices. Initiatives have also been implemented to improve public distribution of food and income-generating programs to enhance the poor's access to it. India is under investing in agriculture compared to other nations since investments are usually reduced more than other expenditures in all sectors, including agriculture, when both public and private budgets are shrinking. In the attempt to handle the load of successive economic and food crises, some bio-nanotechnology breakthroughs will greatly help food security. Thanks to bionanotechnology, agriculture will move from the era of genetically modified (GM) crops to the fascinating new realm of atomically altered creatures. The aforementioned subjects are covered in this essay's three sections: conceptual analysis, the actuality of governmental action, and advances in food security.

OBJECTIVE OF THE STUDY

1. To study about the Food Security and Insecurity in Indian context,
2. To examine Sustainable Development Goal No. 2,





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3. To examining initiatives taken by research organisations to promote eradication of poverty,
4. To find the Strategies of Food Security to achieve the sustainable development goal no. 2.

METHODOLOGY

The current study can make use of secondary data and is grounded on both qualitative and quantitative methodologies. Secondary data were gathered from a variety of official websites, including those of national and international organizations as well as journals, books, papers, and other publications.

DIMENSIONS OF FOOD SECURITY

When everyone has access to enough food at all times, there is food security.

- ✓ is reasonable, secure, and healthy.
- ✓ is socially appropriate.
- ✓ satisfies particular nutritional requirements
- ✓ is acquired for everyone in a respectable manner
- ✓ is generated in methods that are ethical and fair to society.

Security, system, and sovereignty are all components of food security. A part of the food system is...

- all those who cultivate or harvest food, including farmers, fishermen, and hunters
- energy, earth, air, and water (the physical environment) food packagers, marketers, advertisers, and processors (food industry?)
- food wholesalers and the storage facilities for food
- the modes of transportation, including cars, trucks, boats, and railroads
- locations where food is sold, such as supermarkets, markets, bakeries, farm stalls, co-ops, and restaurants
- Institutions that serve meals, such as hospitals and nursing homes
- Governments, laws, and taxes (political and economic environment), the healthcare system, labour force, labour supply, educational system, and technology (the social, educational and cultural environment)
- anybody who eats!

The sovereignty over food is.

Self-determination of peoples and communities so that they plan their own agriculture, labour, fishing, food and land policy which relates with the social labor economic cultures within ecologically sustainable concepts. The right of peoples and communities to define their own agricultural, labor, food, health and development policies; protect the commons; improve soil quality; clean water rights.

THE SEVERITY OF FOOD INSECURITY

Food insecurity and poverty go hand in hand. Food insecurity in India is also brought on by a declining pace of agricultural growth.

- ✚ One billion people are malnourished worldwide, with 800 million of them living in rural regions.
- ✚ FAO: From 2004 to 2006, there were 16% more hungry individuals in developing nations than there were in 2009.
- ✚ Food grain production in India increased from 50 MT in the 1950s to over 200 MT by 2000, but daily availability increased from 395 g to 500 g. (it fell to 445 grammes in 2006)
- ✚ Indians consume 68 kilogrammes of milk and milk products annually per person, compared to 249 kg for Australians.
- ✚ Almost 200 million people are underfed despite their being a food grain supply of roughly 62 MT and an annual requirement of about 20 MT.
- ✚ The discrepancy in calorie consumption between the top and lowest thirds of the population—the top third consumes 2400 kcal—and food poverty is another factor.





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- ✚ More than 30% of mothers and more than 50% of children under the age of six are undernourished.
- ✚ Agriculture's growth rate decreased from about 6% in 1992–1993 to less than 3% in 2006–2007. It was 0.2% the prior year.
- ✚ Agriculture investment decreased from roughly 2% in 1990–1991 to 1.7% in 2004–2005.
- ✚ In rural areas, the annual job growth rate fell from 2.07% in 1987-1994 to 0.66% in 1993-2000.
- ✚ Between the farm and the table, 50% of the food is lost.
- ✚ In India as well, obesity is an issue due to junk food, a lack of exercise, and other factors.
- ✚ Agriculture is not only a victim of climate change but also a contributor to it, making it a severe danger.
- ✚ Other dangers include famine and desertification.

Sustainable Development Goal 2 ("zero hunger")

Zero hunger" is the second Sustainable Development Goal, or Global Goal. It was created in 2015 and is one of the 17 Sustainable Development Goals of the United Nations. "End hunger, establish food security, boost nutrition, and promote sustainable agriculture" was the official name. SDG 2 describes the interactions between the food system, nutrition, rural transformation, and sustainable agriculture. Over 690 million people worldwide, or about 10% of the global population, are estimated by the UN to be food insecure. That indicates that one in nine people never eats before going to bed. This includes the 20 million people who are currently under danger of starving in South Sudan, Somalia, Yemen, and Nigeria. Eight goals and fourteen "outcome targets" make up SDG 2, which needs to be met. The following are the eight "ways of attaining" targets and strategies to support them: increasing access to food and reducing the number of hungry people; eliminating all forms of malnutrition; strengthening agricultural practices and resilient food production systems; preserving the genetic diversity of domesticated animals, plants, and seeds; investing in research and technology; and removing trade barriers, market distortions in international agricultural markets, and food commodity markets and their derivatives. Following decades of reduction, undernutrition has increased since 2015. This is mostly because of the several stresses on food systems, such as the COVID-19 epidemic, the locust crisis, and climatic shocks. Due to the epidemic's stress and rising inequality, the most vulnerable individuals have also suffered from undernourishment due to an indirect decline in their purchasing power and the inability to produce and distribute food for themselves. The study estimates that by 2020, 142 million individuals will have undernourished as a result of the epidemic. Statistics on child wasting and stunting will increase as the virus spreads. Depending on the assumption of economic growth, the COVID-19 pandemic "may add between 83 and 132 million people to the total number of undernourished in the world by the end of 2020." The alarming signs and symptoms of the epidemic persuade us that there is still more work to be done before the entire world "leave no one behind" in the pursuit of a future free from hunger.



PROGRAMS AND ORGANIZATIONS

The following organizations, programmes, and funds have been established to combat hunger and malnutrition: United Nations Children's Fund (UNICEF): In more than 190 nations and territories, UNICEF strives to protect children's rights, save lives, and enable them to reach their full potential. In addition to providing social protection services that ensure children have a healthy diet, UNICEF works to end all kinds of malnutrition by expanding access to high-quality nutrition, healthcare, clean water, and sanitation for mothers and children. UNICEF issued a warning despite its best efforts, saying that in nations like South Sudan where malnutrition is a concern and





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prevention measures are insufficient, the organization will step up treatment and care going forward to ensure the survivors survive childhood and avoid long-term effects.

The Food and Agriculture Organization (FAO); is a specialised organisation of the United Nations that was founded in 1945. Aiding in the eradication of hunger, food insecurity, and malnutrition is one of FAO's strategic goals.

The World Food Programme (WFP): which was established in 1963, is the principal UN body in charge of responding to food emergencies and running global hunger-reduction initiatives. The ECOSOC page above includes reports from the WFP's Executive Board and on its yearly performance.

International Fund for Agricultural Development (IFAD)

IFAD was founded in 1977 with the goal of working with impoverished rural communities in emerging nations to end rural poverty.

World Bank

The World Bank, which was established in 1944, regularly participates in funding food-related programmes and initiatives.

United Nations Environment Programme (UNEP)

Founded in 1972, UNEP is the global organisation in charge of governing and advising on environmental concerns. Food security is one of the subjects the UNEP is now addressing.

Among the international NGOs are

Global non-profit organization Action Against Hunger (ACA) is dedicated to eradicating world hunger. In addition to giving people access to clean water to drink, wholesome food, and long-term solutions to hunger, it assists in feeding undernourished children. Founded in the United States, Feeding America is a nonprofit organization that runs more than 200 food banks. These food banks provide meals to over 46 million people through pantries, soup kitchens, shelters, and other community-based businesses. An organization called The Hunger Project (THP) works to abolish hunger on a sustainable basis. operates long-term, developing-country initiatives inspired by a particular subject, utilizing the tremendous power of rural grassroots communities to achieve family income health education and enduring benefits, spanning Latin America, Africa, and Asia.

OVERALL DEVELOPMENT AND DIFFICULTIES

While progress has been made, research suggests that over 790 million people worldwide remain hungry. Over the last 15 years, there has been real progress in the fight against hunger. In 2017 an event was organized as a side event to the High-level Political Forum on Sustainable Development "Accelerating progress towards achieving SDG2: Lessons from Country Implementation" and several ideas were discussed. It was being led by participants such as the French UN mission, Action Against Hunger and Save The Children in conjunction with Global Citizen. Starvation on the African continent will not have been eliminated by 2030! The world needs political will and ownership from countries to make progress towards SDG 2. It will also need to approach the challenge in a way that deals with issues of gender equity, spatial disparities and extreme poverty whilst enlarging our recognition around nutrition so as integrate into political leaders. It also demands concrete action including working sub-nationally, scaling up nutrition resourcing and a relentless focus on the first 1000 days of life while moving beyond immediate causes to narrow drivers of under nutrition as well as systemic elements along the whole food system.

The WFP Hunger Map displays information about world hunger in 2019

Mention of Important Value Chains and Food Systems by SDG 2 Targets are Ignored SDG 2 targets speak to increasing agricultural productivity and incomes of small-scale farmers, but larger-scale farmers can also earn little from farming; acknowledges 'sustainable agriculture' with no mention as what sustainability entails in any great detail; ignores the health dimensions associated with such diets. Also, the data needed for SDGs monitoring may not always exist (and be tailored) to capture nuanced relationships between the numerous goals of this overall agenda—





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as a considerable share of indicators currently used in support of SDGs monitoring were never designed specifically with respect to that global framework. SDG 2: SDG 2 progress is hampered by the lack of integrated or coordinated action at all levels, from food production to consumption. Melanesia conducted the first evaluation of SDG 2's food security targets in 2021. Reviews and research have concluded that the underlying root cause of people's bad health in this region is a "global syndemic" of obesity, under nutrition, and climate change. Progress under SDG 2 has been achieved in reducing stunting and wasting, however there is still a long way to go to slow the increase of diet-related non-communicable diseases (NCDs) and achieve food security across PSIDS. Urbanisation, changing lifestyles, imported diets and deforestation are eroding traditional agricultural biodiversity as well as the knowledge of smallholder food systems for Melanesians. Transitioning from conventional diets to smart nutrition will likewise accelerate global hunger. The review highlights that the long term goals for SDG 2 should concentrate largely on forging stronger ties between agriculture, nutrition and health.

GOALS, INDICATORS, AND DEVELOPMENT

SDG 2: The UN has defined constitutional framework based on 8 targets with regards to SDG and additional indicators of the same. It need to be completed by 2020, four of those must have been finished at some point in the decade and three are without a deadline. In addition, for each goal there are one or more indicators which follow up on progress. For SDG 2 the total number of indicators equals fourteen. The six objectives are:

- a universal supply of wholesome food
- Put an end to all types of hunger
- Boost the earnings and productivity of small-scale food producers by twofold
- Resilient farming methods and sustainable food production
- Keep the genetic variety in food production intact.
- Invest in technology, gene banks, agricultural research, and rural infrastructure.
- Prevent export subsidies, market distortions, and trade prohibitions pertaining to agriculture
- Assure steady markets for food commodities and prompt information access.

Food Security Techniques

- With an anticipated 9 billion people on the planet in 2050, productivity will need to quadruple to keep up with diminishing and degraded resources. India must produce 60 MT more rice than it produces now by the year 2030. Both agronomists and policymakers must overcome a significant obstacle.
- Appropriate solutions are needed in order to address vulnerabilities and modernise moderately. These are some things that maybe work on this moment. food production: raise the speed of food and having crop, area specific yield & productivity differences in agriculture which decreases (geo-specific food security) 4-5% agricultural growth rate Creating an Agriculture base literacy around the nation (like farm schools, etc)
- This includes any business implications (e.g., investment management, capital expenses and costs vs. benefits), that a farmer should be alerted about. instead: circular economy + organic manure (using biofuels, etc.), without synthetic pesticides and tackling the GM seed issue) = enhanced biodynamic farming.

Post-harvest management is required in agribusiness

We need innovative bold agri-entrepreneurship strategies for all-around success of not just crop management but also food management, knowledge and quality as this is what will determine the pace. For example, how should agri-entrepreneurship be developed within the greater context of social entrepreneurship that is nested on an environment-enterprise nexus building and managing natural (and in this case as well as with scarce examples material) capital. The right solution is that economic and political decisions must serve farmers, the environment, and democracy. making sure institutional reforms align with technological changes (eg. cheaper and cleaner energy technologies). The ultimate objective is 100 per cent financial inclusion as well: minimising agrarian distress and aiding in risk mitigation on-farms & off-farms, including the move from micro to macro financing with access of intermediation. This should be de-politicised and it may also need to remain a BEAUCRACY for sometime till the nation gets larger doses of bureaucracy immunisation. Growing civil society initiatives to improve production, management, delivery and research on stewardship of food in good governance



**Suriya Kumari and Candida Smitha****2nd Green revolution + Gramme (village) revolution → gene revolutions**

Highlighting these include scoping financial inclusion focusing on reach, dealing with poverty as an insecurity issue and new commercial opportunities for self-help organisations (SHGs) creating composite indicators of livelihood and food security (from production to acquisition, entitlement). And from the realization that both intellectually and in practice, policy making can never exist on its own. It is interdisciplinary and links in various social, economical, ecological and developmental facets that are pertinent to the economy as a whole but more importantly food security.

OBSERVATION AND CONCLUSION

We need food security of the individual, household food securities united at district level to feed into national and global. The Agriculture Department needs to promote an Integrated Farming System (IFS) for uplifting crop yields in India. The environment aside, the other issues include food vs. productive (healthy) food ethnic influences etc. No food security policy should be created at the cost of a farmers dignity. Notice being given for food security bill into some regions is being introduced the partnership of private-public. All food security actors must cooperate and articulate their goals. Disbursement of treadle pumps will, however create untapped resource development so as to change the course for low-income farmers and those who have lacked land lease rates in the agriculturally-lean eastern and north-eastern regions. This way, in the water-abundant areas of both countries, millions of micro-economics units will be developed that ensure use for sustainable management and livelihood. Low-cost water-saving devices will allow even the poorest sections of communities to engage in irrigated agriculture with almost no water, such as farmers producing \$2 tomatoes under plastic multiple kilometres away from trees – a demonstration project focusing on permanence means that people are left untouched (they remain unperturbed) and 30 land-based projects enrich more every week. We need to create and make plans in such a way that more bio-fertilizers are used, the method of farming should be sustainable. Small and marginal farms can be offered subsidies to adopt biogas plants as well as modern composting techniques. Community-based programmes for enhancing biomass production from common property wastelands can also be looked at. Training oriented extension activities are required on efficient composting, organic farming practices; biogas and low cost water saving technology is carried out. Further research in agriculture should not only be converted one from supply side to demand oriented by integrating physical and socioeconomic conditions because of the boundaries involved as facets. By reducing the aggregate demand face of water in agriculture, these reforms to make private and tradable some rights about controlling who gets how much water from public reservoirs — together with using farmers' right-based groundwater powers on those reserves for good or rental reasons – have significant potential to change farm outputs. It will also bring more access and control over the groundwater as well as managing dopa irrigation waters for food production and household foods security.

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A Critical Examination of Mahila E Haat and National Rural Livelihood Mission Schemes – A Game Changer in the Financial Empowerment of Rural Women of Tumkur District, Karnataka

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ABSTRACT

This paper critically examines the MAHILA E HAAT initiative and various schemes of National Rural Livelihood Mission (NRLM) which have created transformative change in financial empowerment among rural Women Entrepreneurs(Tumkur District, Karnataka.). This paper analyzes the effectiveness, problems as well constraints of these schemes and also to examine extent they can act as a change agent in improving women's life particularly rural. The analysis of the implementation, results and feedback from different stakeholders will thus seek to provide useful information did needs response on how these initiatives can foster de empirical landscape Forward while empowering women in this particular region.

Keywords: Economic Independence, Economic Empowerment, Financial Empowerment, National Rural Livelihood Mission, Poverty Alleviation.

INTRODUCTION

Rural women play an important role in the socio-economic fabric of India and their economic independence is one of the main drivers for national development. Against this backdrop, the significance of MAHILA E HAAT initiative and NRLM schemes at reclaiming rural women for Tumkur District (Karnataka) women economic status are explored.



**Sharada and Nirmala****Background**

As a predominantly rural district, Tumkur reflects the complex intricacy of challenges and opportunities interwoven into lives of its fairer sex. Projecting power of financially independent women in transformative community development, the launch MAHILA E HAAT and NRLM schemes are powerful narratives.

Significance of the Study

Getting knowledge of these schemes is very important to know their actual effect on the ground where Rural Women are residing. This study hopes to unravel some of these characteristics beyond quantitative assessments, particularly in terms of understanding the qualitative side of empowerment and learning from experiences — which may inform future ways forward for beneficiaries as well a wider efficiency enhancement involving such initiatives.

Objectives

1. To research on dependency and development levels (financial) among the rural women in India
2. To assess the extent of Mahila E Haat in Creating Entrepreneurial opportunities for rural women.
3. What role do the NRLM schemes play in empowering women financially in villages of Jonawada Constituency?
4. Implementation challenges of MAHILA E HAAT and NRLM schemes?
5. How much game changing are these initiatives in bringing economic empowerment among the women of rural areas.

METHODOLOGY

The study uses an integrated research approach, exiting collection data from multiple sources such as reports, documentation and interviews with key stakeholders. For the assessment of impacts and effectiveness, qualitative analysis will be adopted in MAHILA E HAAT and NRLM schemes. Study involves synthesis of data from collected Secondary data through reports, documentation and stakeholder feedback related to MAHILA E HAAT and NRLM schemes.

The importance of financial empowerment on overall development of rural women in India.

How financial empowerment is significant towards the holistic rural women development in India and way forward. Some of the significant aspects to throw light on regarding financial empowerment are:

- **Economic Independence:** Financial empowerment helps to equip women in the rural area with a means for making money on their own so that they will not continue asking people around them as such reducing dependency and opening up an economic independence. This empowerment gives them the ability to make decisions around money, earn part of their own income and work towards living a life on their terms.
- **Poverty Alleviation:** Rural women are able to experience a reduction in poverty through their engagement in income-generating activities and accessing financial resources, which they can infuse into their households and communities. Financially empowering families opens the door to ensure that entire communities are lifted out of indigence.
- **Education and Skill Development:** Women who are financially empowered often think about investing in education & skill development for themselves as well as their children. This helps in building up human capital in the community, having a positive impact on future generation and breaking intergenerational cycle of poverty.
- **Health and Wellbeing :**More resources of money means better health conditions, access to healthcare facilities, nutritious food intake etc. When women are financially empowered, households allocate money for health and healthier families result in healthier communities.
- **Entrepreneurship and Livelihood Opportunities:** It enables rural women to start small businesses or entrepreneurial ventures. Not only that it lifts up their economy but also helps in the local economic development and locals are getting employment.





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- **Women Empowerment and Gender Equality:** Access to finance is the essential driver for women empowerment as a whole. This gives girls the self-assurance and confidence to take part in decision-making, defy gender norms & stand up for their rights. This, in turn helps to create more gender equitable families and communities.
- **Community Development:** Economically empowered women are known to give back in productive ways by helping improve local infrastructure, assist with education and be a part of social projects beneficial for community. These combined efforts contribute towards complete rural development.
- **Resilience to Shocks:** The women who are financially empowered will be able stand against sudden economic shocks and uncertainties. AJ: What we know from research is having savings, access to credit and multiple sources of income will insulate families against any kind of shocks that come their way which ultimately makes them more resilient.
- **Access to resources/market/opportunities:** Economic empowerment improves access for women to be able go-outs and as well focused group discussions. Empowerment refers to the increased participation of women in economic activities beyond traditional roles, which makes them broadened and result an important stimulant for overall community development.
- **Social and Cultural Transformation:** As for as the social perspective is concerned; when a community starts earning money with their own potential lots of positive changes occur in society. Women engage in compensation for their work, it changes society to know that women make a significant contribution and the community emancipates.

The impact of Mahila E Haat in fostering Entrepreneurship among rural women.

Entrepreneurship Promotion

- **Impact:** A platform for rural women to display & sell their products, promoting entrepreneurship.
- **Good result:** This platform can be useful for women to introduce local handmade and traditional businesses(artisans) with the main aim of selling their products (local, handmade or artisan).

Market Access

- **Impact:** Women entrepreneurs can access a broader market online from local communities.
- **Good result:** improved access to women-owned products, which facilitates exposure and transactions between producers/suppliers of business opportunities.

Financial Independence:

- **Impact:** Economic empowerment of women — through enabling her to earning income from their entrepreneurial ventures. So a man who earns in the region of €250,000 can afford children and support his wife if she choses to stay at home (but obviously think about putting your eyesight onto optimum fertility) but as it takes two years from fat sperm trying again after an "accident" decides what you're doing with him during maternity leave seems like you've got everything mixed up.

Skill Development

- **Result:** Skill Development, Creativity amongst Women.
- **Positive Outcome:** As a result, women not only acquire economic skills but also get business acumen, how to market their products and financial management which builds on the entrepreneurial capabilities.

Diversity of Products:

- **Impact:** Mahila E Haat works towards diversifying the product base of women entrepreneurs.
- **The Good News:** This diversity breeds innovation and provides that women have access to all market segments, meeting different consumer needs.

Networking and Collaboration:

- **Impact:** The platform allows women entrepreneurs to connect and collaborate with each other.



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- Collaborations can also give rise to shared assets, partnerships and a positive atmosphere which is great for business thriving.

Cultural Preservation:

- **Impact:** Mahila E Haat Sale of handmade and traditional products are promoted through this initiative.
- **Positive Result:** This leads to the Conservation and dissemination of cultural heritage, for women in turn creates; Content that helps preserve traditional workers.

Increased Visibility

- **Result:** Provide women entrepreneurs at national (and global) level visibility.
- **Impact:** More visibility = more customers/clients and increased presence in market for women entrepreneurs.
- **Positive Outcome:** Greater discoverability creates an opportunity to reach a larger demographic resulting potential increase revenue & marketplace currency>.

Capacity Building

- **Action:** Empowerment of women entrepreneurship under Mahila E Haat can solve the capacity problem.
- **Benefits:** Market Reach, customer and business feedback become an opportunity to hone relevant skills for better negotiating in the world of Business female entrepreneurs. It should be remembered that the extent of Mahila E Haat in fostering entrepreneurship among rural women may differ from region to regions and community to communities. Measuring the effectiveness of the program would include tracking how many more women-led businesses have started, changes in incomes and overall economic self that participating has entailed for these other – but by no means all — women. There is also a much more detailed information available through official reports, case studies or evaluations of Mahila E Haat) that can provide an accurate and updated picture.

The financial independence of rural women in Tumkur District; A case study: NRLM Schemes**Overview of NRLM**

The National Rural Livelihood Mission (NRLM) is a flagship programme of the Ministry of Rural Development, Government of India being implemented across all states by taking into account local socio-economic factors.

Implications for Financial Inclusion**Livelihood Promotion:**

- **Target:** Improving livelihood opportunities for rural women.
- **Mechanism:** The NRLM supports a range of livelihood activities including skill development, enterprise training and access to credit so that women in rural areas are able to set up income generating units and sustain.

Self-Help Group (SHG) Formation

- **Aim:** Cultivating community power and economic empowerment
- **Mechanism:** NRLM works on the formation and capitalization of SHGs to enable resource pooling, credit access, combined ventures by women resulting in improved fiscal security.

Credit and Financial Services:-

- **Principle:** Regulate to expand financial inclusion and use of credit.
- **Function:** NRLM is intended to provide the poor, rural women direct access to micro-credit and savings alongside insurance facilities for empowering them with funding of different items, both consumable as well as non-consumables.

Skill Development and Capacity Building

- **Aim:** Improve income-generating capacity
- **Mechanism:** NRLM aims to empower rural women by offering skilling programs where they are trained in a variety of trades and crafts which helps them be employed and earn an income.





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Enterprise Promotion

- **Objective:** Encourage creation and expansion of entrepreneurship and enterprises.
- **Mechanism:** NRLM promotes and supports rural livelihoods for women by setting up or expanding businesses which result in higher household income generation ensuring self-dependence.

Market Linkages

- Facilitate market linkages for rural producers.
- The goal is that NRLM needs to be robust mechanism with appropriate policy enablers in place so as rural women produce sustainable products provide them away of life line for selling the same at a reasonable price by entering dealers / retailers giving viable and increased income under product trading post sale.

Social Mobilization and power

- **Objective:** To make the advancement of rural women in social,.
- **Mechanism:** NRLM promotes social mobilization and empowerment interventions that would require women to play a leading role in the decision-making processes, thereby scale up inclusive participation particularly from gender lens for development.

Natural Resource Management and Sustainable Agriculture

Objective: To increase sustainable agriculture practices.

Procedure: NRLM promotes organic agriculture and sustainable management of natural resources among the women beneficiaries who engage in rural productive activity. The NRLM schemes can be added to this during the time of implementation such as new being implemented now or planned by GoK in future Learn more For up-to-date and detailed information on how individual NGOs do financial empowerment for rural women, please refer that official report; district level NRLM document go Debug (Provide) source etc Rather than giving state wise funds received from MGNREGAS it is best course if while communication via Channel iGuess-income-increment-policy, one should ask them: Based on materials that we have reviewed you are also implementing. Which all? Why not include hereLet's get specifics regarding what your organization does towards doing bank accounts for Women want might financially empowered(mastered defining Income Increment Policy clearly)?

What are the challenges faced in implementation of MAHILA E HAAT and NRLM schemes?

Specific challenges may differ with respect to the local context as well as on a case-to-case basis but some common issues faced while implementing under schemes such MAHILA E HAAT and NRLM scheme are:

Challenges in MAHILA E HAAT

Limited Digital Literacy

- **Challenge:** most women, especially in rural areas do not have access to and familiarity with digital technologies that prevents them from being involved into an online marketplace (MAHILA E HAAT).
- **Result:** Extensive digital literacy programs can be weaved in to add value and touch upon various parts of the ecosystem.

Logistical Constraints

- **Challenge:** As in any remote area, there might be challenges with logistics (delivery of goods and product transportation).
- **Problem :** There is a need for efficient delivery mechanisms and solutions to overcome logistical bottlenecks, which would make the platform more functional.

Product Quality Assurance

- **Challenge:** It is difficult to monitor quality of the products on sale and question may be raised for satisfaction level by customer & credibility by MAHILA E HAAT.



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- **Solution:** To overcome this issue, quality control measures have to be taken and working on product standard training with certification processes.

Market Competition

Women entrepreneurs are increasingly entering into e-commerce, but being seen in the online market and shining among its products is another challenge.

The way to introduce those extra features is marketing support, branding assistance and how the product be introduced in program.

Challenges in NRLM Schemes**Limited Access to Credit**

- **Problem:** While expanding credit can create an access banks might not in those places, some women face additional hurdles to qualify for loans.
- **Solution:** This problem can be addressed by increasing the financial linkages, imparting literacy about finance and augmenting accessibility to banking facilities.

The Lifetime of Livelihoods

- **Challenge:** One concern will be how livelihoods created through NRLM can be made economically viable in the long-run.
- **Solution:** including market linkage strategies, sustainable livelihood practices and long-term support and mentorships can help make sustainability profits.

Social and Cultural Barriers

- **Challenge:** Women maybe prevented from participating in economic activities due to entrenched social and cultural norms.
- **A potential solution:** programs to deconstruct these hegemonic masculinities and promote gender neutral practices through the use of sensitization, community engagement and awareness.

Monitoring and Evaluation

- **Hurdle:** Monitoring and evaluation of the impact from NRLM schemes require reliable systems, which may not be functional in several areas.
- **Resolution:** The issue can be addressed through the facilitation of adaptive management wherein, a system is strengthened with monitoring and evaluation mechanism using technology along with active participation from local community in assessment process.

Infrastructure and Connectivity

- **Challenge:** Absence of appropriate infrastructure, lack of connectivity in rural areas can hinder smooth implementation of NRLM.
- **Answer:** Investment in rural infrastructure such as roads and communication networks improves overall connectivity / accessibility. Overcoming this challenge will entail a comprehensive response, including cooperation of government agencies with NGOs and local communities to implement the MAHILA E HAAT programme as well as schemes like NRLM in an effective manner.

But to what extent are these initiatives game-changers in empowering rural women economically?

The game-changer in improving the economic condition of rural women or designed impact through schemes such as MAHILA E HAAT and NRLM would depend on program efficacy, local conditions, community involvement etc. We explore the most important factors when considering each here:





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MAHILA E HAAT

Market Access and Visibility

- **Potential for Impact:** MAHILA E HAAT is projected to enable rural women, artisans etc sell their products and services by releasing them from the limit of local reach.
- **Game-Changer Factor:** The platform has the potential to raise rural women out of poverty and into better economic situations by opening them up to a larger customer base granted that it is promoted well enough, creating other ways for customers in order convenient services Board Members participated more actively diff. Have there been entrepreneurial opportunities?

Description of Impact

Making women entrepreneurs by selling handmade, handicrafts and traditional art products. Why MAHILA E HAAT is a Game-Changer: With this rise in Internet usage, it will be instrumental to accelerate entrepreneurship and provide women an outlet to use their skills & creativity for economic rewards.

Financial Inclusion

Potential Impact: Online transactions, the golden rule within e-commerce is that you should ease on of these to conduct.

Game-Changer Factor

MAHILA E HAAT can be a game-changer, if successful in breaking the barriers for hundreds of rural women to have financial access and inclusion hence managing their finances better.

NRLM Schemes

Self-Help Groups (SHG) & The Power Of Collective Block adenone

- **Potential Impact:** NRLM lays great stress on the formation and building up of SHGs, thereby promoting collective savings approach as also participation in decision-making.
- **Game Changer Factor:** As far as women are concerned strengthening of collectives can be the game changer on economic empowerment, so that they could mobilize themselves economically to get better terms in resources/economic activities.

Livelihood Diversification

Probable Development Outcome

Diversification of livelihoods through skill development, and enterprise promotion

Game Changer Potential

NRLM also has the potential to be a game changer in that rural women can diversify their income sources, reduce dependence on one livelihood and improve overall economic resilience.

Creating Market Linkages and Integration of Value Chain

- **Potential Impact:** Linking rural producers to Markets & value chain interventions.
- **The Game-Changer:** With a win, NRLM has the potential to completely change the face of rural women by providing them access to wider markets and ensuring genuine prices for their products.

Sustainable agriculture and natural resource management

Please explain the overall significance Public Awareness: Promoting sustainable agriculture as well in natural resource management.

A Energizing Change

NRLM has the potential to be a game-changer by harnessing and empowering women at rural areas in resource hay practices thereby ensuring long term economic as well environmental sustenance.



**Sharada and Nirmala****Financial Services and Credit**

- **Expected Impact:** Increase in financial and credit services thereby improving the standard of living.
- **Game-Changer Factor:** If implemented as it should, then the NRLM has a gamechanger in addressing one of its fundamental challenges from poor access to credit, which is empowerment for rural women to invest and start livelihood enterprises. To be real game-changers, these endeavours must respond to the myriad realities of diverse communities they serve; celebrate women as active participants in this journey and invest widely into enabling policies and infrastructure development. There is a strong need of constant monitoring, evaluation and adapting as per feedback from ground to ensure sustenance of empowering economic status women residing in rural areas.

CONCLUSION

MAHILA E HAAT & National Rural Livelihood Mission (NRLM) join hands to complement rural development processes in the hitherto most backward District of Tumkur in Karnataka, weaving a narrative that glorifies every woman — who is central to grassroot carrying capacities everywhere. Conclusions On Closing These Examples : This exhaustive analysis of these initiatives makes it possible to reach several key conclusions which we discuss as parting thoughts. MAHILA E HAAT and Entrepreneurship Among Rural Women — A Multifaceted Impact Acting as a virtual marketplace, Splatters has ushered in entrepreneurship by allowing women to exhibit and sell their products. As a result, there has been more money flow new skills and traditional crafts have not died. However, there have been observed challenges of digital literacy and logistical constraints that requires targeted interventions to maintain success. Contrarily, NRLM has been instrumental in the promotion of entrepreneurship through the formation and nurturing of self -help groups (SHGs) as well as various livelihood activities. SHGs have promoted a sense of togetherness among women which provides them strength; collectively they can access credit, become engaged in joint ventures and help each other participate stronger within the decision making process This diversification of livelihoods has made women more resilient towards economic and uncertain shocks. Financial Inclusion and Empowerment of Rural Women in Tumkur District through MAHILA E HAAT and NRLM It has also helped for easy money transactions and financially managed by women SHGs through MAHILA E HAAT's online platform. The aim of NRLM to provide credit, financial services and skill development has enabled women in taking informed decisions towards finance reducing the bottlenecks that arise with low levels of access.

The examination of these two cases brings to surface a series of challenges faced by both. The MAHILA E HAAT faces challenges concerning the digital literacy issues, logistical constraints and product quality assurance. NRLM grapples with problems like limited access to credit, viability of livelihoods, and social/cultural barriers. A critical aspect of the way forward is to acknowledge these challenges in order to come up with strategies and interventions that are contextualized for Tumkur District. The other hand, the exam also emphasized the positive initiatives of these hands on a total community development. MaDHILA E HAAT and NRLM not merely ensure in completing financial independence at the individual level but helps to develop community development concurrently. Together, the saving of cultural heritage and healthcare, education and other facilities like infrastructure improvements have helped changed for a better outcome in this part. In conclusion, it can be derived from the above analysis that MAHILA E HAAT and NRLM have managed to get a large ground but there are some areas which still need attention. Recommendations: Tailored digital literacy programs; Logistics Cutting down the red tape and e-commerce system improvement for MAHILA E HAAT, Targeted interventions to improve credit access and sustainability of NRLM. Enhanced monitoring and evaluation efforts should make sure that they are linked to community insights, leading to sustainable actions. In conclusion, both these programs MAHILA E HAAT and NRLM have become the agent of change in Tumkur District toward economic empowerment for women. As stakeholders and policymakers continue in to the journey, will these insights be their compass leading towards a more inclusive sustainable development for these women who are making Tumkur's traditional rural economy vibrant.





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Impact of Disruptive Technologies on Organizational Effectiveness of Information Technology Industry

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ABSTRACT

The utilization of digital transformations and blockchain technology is crucial in enabling economic progress. This study is highly significant as its objective is to analyze the impact of disruptive technologies on the expansion of information technology (IT) firms in India. The aim of this study is to offer significant insights into the comprehensive performance of the Information Technology (IT) sector. To accomplish the study's aims, a systematic and comprehensive literature review is performed. Disruptive technologies have been seen to augment productivity, boost quality, and streamline usability inside organizational contexts. This phenomena can be attributed to the inclination of disruptive technology to automate manual processes, optimize operations, and eliminate inefficiencies. Moreover, the application of these technologies might lead to improved quality, hence potentially fostering higher levels of consumer satisfaction and loyalty. This study offers valuable insights for managers and decision-makers in these organizations, allowing them to identify specific areas where disruptive innovations can have a significant impact on important performance metrics, such as revenue growth, market share, and customer satisfaction. The results of this study might significantly contribute to the development of a theoretical framework that efficiently utilizes disruptive innovations to improve corporate performance in the IT industry in India.

Keywords: Disruptive technologies, organizational effectiveness, Information technology, Industry 4.0





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INTRODUCTION

The importance of Industry 4.0 in the Indian economy should not be underestimated. India, a rapidly developing nation, has a great predisposition towards embracing technological advancements to boost its economic growth and global competitiveness of Industry 4.0, with its focus on automation, artificial intelligence, and data analytics, has the potential to bring about major transformation in several sectors in India, such as manufacturing, healthcare, agriculture, and logistics (Viraj Vijay and et al, 2019). Indian IT firms possess the capability to make a substantial impact on India's digital revolution and economic progress by employing innovative concepts and establishing reliable assessment mechanisms to analyze crucial performance indicators (Rawat, Pratih & Purohit, Jayant, 2019). Furthermore, the use of Industry 4.0 technologies has the capacity to improve production and efficiency in these sectors. Within the realm of manufacturing, automation possesses the capacity to optimize production processes, mitigate mistakes, and bolster overall quality control. Artificial intelligence (AI) can have a substantial impact on the healthcare industry by aiding in the early identification of diseases and enabling personalized treatment methods (Hoyer, W. D., et al. 2020). Moreover, the application of data analytics has the capacity to enhance agricultural operations, leading to higher crop output and more efficient allocation of resources. The full implementation of Industry 4.0 has the capacity to position India as a significant player in global innovation and propel its economic progress on the world stage (Cirillo, V., et al, 2023). Disruptive innovations refer to the introduction of new and unique products or services that cause a significant and fundamental change in an industry or market (Si, S., & Chen, H., 2020). Often, these technological improvements provide significant difficulties for established businesses and their operational structures, forcing them to adapt their tactics or risk becoming outdated (Palmié, M., et al., 2020). Disruptive innovations have become highly significant in the IT sector in India, considering the industry's rapid and sustainable expansion. The assessment of the efficacy of disruptive technologies is largely dependent on crucial performance metrics, such as revenue expansion, market dominance, and customer satisfaction (Coccia, M. 2020). This research aims to investigate the impact of disruptive technologies on the overall performance and competitiveness of certain IT firms in India by analyzing key characteristics (Wang, C., et al, 2023). The importance of digital transformations in promoting economic prosperity is significant. This study is significant as it aims to assess the influence of disruptive technologies on the growth of information technology (IT) companies in India (Antonio, J. L., & Kanbach, D. K. 2023). This research seeks to provide valuable insights into the overall performance of the IT industry by evaluating crucial performance indicators, such as Productivity, customer happiness, Quality, and ease of use, in connection to the influence of disruptive technologies.

RESEARCH METHODS

The study aims to examine the influence of disruptive technologies on the organizational effectiveness of the IT sector. Consequently, the investigation employs a methodical process that requires analyzing secondary data, resources, and previous investigations. Several academics have asserted that performing a systematic or semi-systematic literature review, together with analyzing secondary data, might enhance researchers' understanding of the topic under examination. This technique guarantees that the study is grounded in empirical or empirically validated data, since it is the sole approach that facilitates the identification, analysis, comprehension, and synthesis of the ways in which artificial intelligence has modified and influenced education and its outcomes. This study employed a systematic literature review approach to analyze previous scholarly works that were pertinent to the research inquiries under investigation. The articles were sourced from reputed journals and were scrutinized to determine the level of quality exhibited by each study. Elsevier database, Routledge and CRC Press Taylor and Francis database. Emerald Group Publishing database, Springer Nature database and Sage database. Several supplementary articles were acquired from reputable academic databases such as Wiley, Academia, JSTOR, and Guildford Press





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RESULTS AND DISCUSSION

In November of 2008, Satoshi Natamoto published the popular paper "Bitcoin: A Peer-to-Peer Electronic Cash System" under the pseudonym Satoshi Natamoto. The idea of using cryptography and TCP (internet) to allow a distributed currency system without a central or regulating authority was first proposed in this article. In terms of technology, block chain is a large database that is distributed/shared by users in order to maintain data consistency. Rather than being handled by a single entity, this database is managed by a group of people, or all peers in a network. Asymmetric cryptography, also known as public key cryptography, is used to complete the exchange using a pair of digital keys. This is so for all types of block chain databases. States (a snapshot of asset/value ownerships) and transactions that change the state make up a block chain ledger. Bitcoin is an example of a stateless protocol that consists solely of transactions. Some protocols just keep track of the most recent condition and transactions. Both block chains, however, have transactions stuffed into blocks with other data such as the hash of previous blocks' header to guarantee that the block chain has not been tampered with. When two parties agree to transact, they send their transaction to the network over TCP and it becomes part of a nominee block (Chege, S. M., et al .2020). To verify transactions, permanently record the candidate block in the block chain ledger, and guarantee that all nodes obtain the most recent version of the ledger, the protocol requires a consensus mechanism. Three criteria direct block chain implementations: trust vs. no-trust, public vs. secret, permissioned vs. permission less. With the increased use of cloud technology by various industries and organizations, the cost of implementing block chain has decreased. Now, all digital contracts and peer-to-peer data can be stored in cloud platforms, where storage costs are significantly lower, and all cloud providers are attempting to promote their offerings in respective cloud to give organizations a competitive advantage. (Hoyer, W. D., et al . 2020).

- For starters, the lack of clarity in terminology and terminologies, as well as the difficulty in understanding it at different stages, make it challenging for novice users to grasp and execute it. Furthermore, as more R&D operations take place, the frequency of adjustment to this platform increases, making things much more complicated.
- Second, throughput and power problems would make scaling up and mass adoption more difficult. For eg, in order for a banking network of millions of consumers to be block chain powered, we need a high rate of transaction per second, similar to that of Twitter and Facebook. Currently, block chain throughput is a fraction of that, making large-scale implementation all the more difficult.
- Third, from the standpoint of user friendliness, using the Application programming interface - API has its own set of challenges. There are different API, such as payments receive API, wallet API, data API, demand API, real-time updates API, exchange rates API, and so on. The APIs available are not in a standard format and are not convenient to plug and play in an application; instead, they must be customized to fit with a specific application.
- Fourth, there is a significant amount of energy lost in mining in order to execute the high-end computation algorithm; there is a lot of opportunity to eliminate this.
- Fifth, usability: Designing services for the Bitcoin API is challenging. There is a need to provide a developer-friendly Block chain API. This could be compared to REST APIs.
- Sixth, various chains, rough forks, and versioning: A 51 percent attack is more likely to occur in a short chain with a small number of nodes. When chains are broken for administrative or versioning reasons, another problem arises.

According to Accenture experts, the world banking industry could save up to \$20 billion by 2022 by introducing block chain. Although block chain is being introduced in a variety of industries around the world, the banking industry would be the first to benefit. The below are the key ways in which banks and other financial institutions may be able to use block chain technology:

1. Faster international transfers and lower costs: Large financial institutions and independent financial experts see block chain technology as a potential replacement for the SWIFT bank payment mechanism in the near future. Costs will be reduced, and bank-to-bank and foreign transactions will be quicker.





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2. Simplified Client Identification System: Another area of block chain application in the banking industry is the implementation of a distributed ledger-based client identification system. Since all credit institutions must execute KYC while handling applications, this is extremely important. Users may be detected on a single occasion via block chain, and this information is safely stored with access given to all banks in the scheme.
3. Decentralized Loan Disbursement: Insuring deposits and loans is a direct result of banking and financial practices. Also in developing countries, the majority of these banking functions are often criticized as inefficient and vulnerable. Private bank deposits in common currencies are insured by state regulators. A distributed mechanism for loans and deposits based on ledger technology is decentralized, and the system cannot go bankrupt because the deposits are not managed by one entity.
4. Insurance Automated Payments: In the financial sector, decentralization ensures stability and reliability. Another important way to boost standard insurance is to automate settlement on insurance claims. People would be able to collect payments directly if the scheme is based on smart contracts that are executed seamlessly and do not entail lengthy procedural waits requiring several managers.

(White, Gareth, 2017) While block chain has the potential to become a significant source of disruptive innovations in business and management, it is critical to understand and identify the areas in which there is a business case for implementing block chain techniques. To arrive at this conclusion, this paper employs Delphi Techniques to conduct a thorough investigation. Business managers must be aware of the potential impact of block chain techniques; this study outlines numerous ways in which it can be used to further shape business processes, as well as a few areas in which it can be applied in the development of innovative and valuable new business processes and products. This paper focuses on the impact of block chain technology on the business management discipline; however, due to the small sample size available, the examination of future applications is limited in this paper. In addition, because of the low rate of knowledge, only a small number of panel members were able to envision future applications. Furthermore, this paper does not consider the impact of Block Chain on society. **(Horia Mircea, Botos, 2017)** Block chain is defined as the decentralized ledger that records all of the transactions. This paper also describes bitcoin intelligence steps and procedures that will assist a bitcoin user, owner, or broker in making the best decision in order to maximise their profit and financial security in the cryptocurrency market. In order to better understand bitcoin and increase its acceptance, it is necessary to gain a better understanding of its market and users, as well as the development of the cryptocurrency and its competitors. According to **Nakamoto (2009)**, the founder of Bitcoin, in his paper proposed an electronic transaction that did not rely on trust, and proposed a peer-to-peer network that used a proof-of-work system that added transparency by recording a public history of transactions that an attacker could not change because the honest nodes controlled a majority of CPU power. Businesses benefit from Business Intelligence, according to **Rouse and Stedman (2014)**, who explain how it helps them make more informed decisions. The research presented in this paper concentrated on Business Intelligence and its application of crypto currency, but it did not address the qualitative aspects of operational performance in any way. **(Jeremy M Sklaroff , 2017)** Smart contracts are computer code-based decentralized agreements kept on a blockchain network of computers. Smart Contracts aim to eliminate the expensive process of contract formation, the need for court intervention, opportunistic conduct, and the inherent uncertainties of written language, while simultaneously reaping advantages. When contracts shift their focus away from the person, they give rise to new forms of inefficiencies. The outcomes are caused by automation, which necessitates the use of fully defined terms in every agreement, decentralization that improves performance through third-party verification, and anonymity that eliminates the reliance on commercial context to interpret agreement terms. Consequently, creating a smart contract in an unstable environment incurs high costs. The main emphasis of this study was on flexibility and semantic contracts, as well as flexibility and EDI, and flexibility and smart contracts. However, the specific methods and strategies to reduce costs while ensuring flexibility in the implementation of smart contracts, as well as the necessary changes to tools and systems for more effective implementation, were not addressed.

Disruptive technologies and Organizational effectiveness

(Grenčíková, & et al, 2020) The Fourth Industrial Revolution has resulted in significant technological, demographic, and socioeconomic developments that have an effect on almost every aspect of industry. Both a labor glut and the



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emergence of entirely new careers are anticipated in the human resources sector. The ideology of Industry 4.0 has a huge impact on labor production in individual countries, and the Slovak Republic is no exception. Not only commercial businesses, including all sectors of the labor force would be affected. The aim of this analysis is to examine the potential production of labor productivity in Slovak companies and to forecast its growth over the next few years, taking into account the effects of a shrinking working-age population on the formation and termination of employment and occupations. A primary analysis instrument used to evaluate the survey findings was a questionnaire sent to 319 businesses in the Slovak Republic, with a response rate of 228. The results suggest that, while the labor force in the Slovak labor market will not grow, it will shrink as a result of unfavorable demographic trends. The use of emerging technology would improve overall efficiency in Slovak businesses. The findings show that the Industry 4.0 definition would have a big impact on labor efficiency in the global economy as well as in the Slovak Republic. The guidelines, in particular, are intended to draw attention to improvements in work structure and the need for school reform as a result of Industry 4.0 criteria. **(Backhaus, Simon & Nadarajah, Devika. , 2019)** Previous Industry 4.0 research in Malaysia has mostly focused on cloud manufacturing, automated robotics, and intelligent manufacturing. The beer and electrical equipment industries were the primary subject of the field studies. Industry 4.0 is thought to be the start of a new industrial revolution.

Unlike previous papers, the goal of this strategic report is to provide a conceptual basis for future research in Malaysia aimed at determining the relationship between Industry 4.0 core technologies and productivity. There are also a number of large-scale field experiments on Industry 4.0 and the competitiveness of Malaysian manufacturing firms. The paper summarizes the primary innovations of Industry 4.0 and lists them by absolute frequency as reported in the literature. The research issues that have been raised are about the interaction among competitiveness and Industry 4.0 technologies. Productivity is a critical component of manufacturing firms' productivity. As a result, prior to implementing new manufacturing technology, Malaysian manufacturing firms must conduct research into the relationship between Industry 4.0 technologies and productivity. **(Hercko, Jozef & Slamkova, Eva & Hnat, Jozef. , 2015)** Based on the ideals of the Industry 4.0 definition, this article contains fundamental information on how to improve efficiency. Based on this definition, the article describes the fundamental factors and processes for increasing productivity. This concept's application provides high-added benefit to both the enterprise and its consumers. Companies are able to manufacture goods in one hand while still meeting the demands of consumers in the other. **Del Giorgio, Horacio & Mon, Alicia. , 2019)** Information and communication technologies (ICTs) are a critical component of industrial growth on the path to digital transition, which necessitates the implementation of Industry 4.0. The effect of emerging technology in the industry allows for the early identification of defects, process change, and production time reduction. There are forces that have the potential to dramatically alter output levels in various manufacturing sectors. While various Software Products are currently used in various industries' management, marketing, and logistics systems, the integration of technology into the automation and regulation of manufacturing processes is causing a new industrial revolution that is altering the process control model, directly affecting efficiency and competitiveness. The software industry is faced with the task of creating open and functional products for individual consumers by studying their habits, knowledge, and attributes in order to incorporate methods that can be applied to industry-specific manufacturing processes and knowledge.

The application of usability strategies to the production of products that can be applied in the manufacturing sector, regardless of branch of operation, is discussed in this paper, and a model of the Design/Development Process of Specific Software Products for the Industry is proposed for this reason. This model adapts and customizes various usability approaches to the unique characteristics of this class of user in their actual usage sense. **Walsh and Kirchhoff (2000)** used the following model to provide a relevant overview and provide insight into the term disruptive technologies: The paradigm visually demonstrates the differentiation between transformational and lasting technologies (Walsh & Kirchhoff, 2000). Disruptive technology has the potential to completely eliminate current advancements in a firm. The genesis of groundbreaking innovations can arise from either exogenous input or the initial concept or hypothesis, both of which can be derived from the utilization of information technology for a company's core capabilities. If the customer acknowledges the potential of disruptive technologies, it will drive the introduction of a product that just substitutes or supersedes the current technology. Disruptive technology





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distinguishes itself from sustaining technology by its capacity to eliminate or supplant supporting technology. Conversely, updating the hardware might be advantageous due to recent or substantial enhancements in the gadget. Evolutionary or lasting technology is characterized by its capacity to persist as the most current technology utilized by the organization. If a product is propelled to the market by lasting technology, it simply means that it is built on current technology but with extra features that may include a new and major improvement depending on client or company demands. Based on the model, it can be inferred that disruptive technology is distinct from enduring technology in that it is a contemporary and inventive technology that replaces or causes the discontinuation of current technology, making it outdated and effectively eliminating it. Sustaining technology necessitates the continuous progression of existing innovations. Creativity, in relation to maintaining technologies, refers to the process of enhancing or modifying current technologies with novel or substantial alterations. According to Walsh and Kirchoff's (2000) findings, it was challenging to recognize a new technology before it was implemented and adopted by different customers. Predicting the effects of emerging technology on a market or the specific sector it may disrupt is exceedingly difficult. The features of disruptive technology can offer guidance on identifying when a new technology has the potential to become disruptive.

S-Curve Framework for Disruptive Technology

The corporate climate can utilize the value network to evaluate a company's performance. Given the significant impact of the value network on a company's performance, it is imperative to take into account the implications of the value network while strategically planning for information technology. The S-Curve approach is employed in strategic forecasting to predict the outcomes of a corporation. The S-Curve principle is frequently employed to illustrate the progressive enhancement of a product's uniformity over a period of time (Christensen, 2000). The S-Curve framework is frequently employed to predict the result when a prevailing technology is at risk of being replaced by a novel technology. Managers in the digital economy are confronted with a substantial and rapid increase in technology innovation, which has the potential to significantly alter power dynamics and create wealth in almost every sector. The S-Curve manufacturing line serves as a mechanism for monitoring and evaluating product outcomes. A product line that exhibits a continuous S-curve pattern adheres to the typical life cycle of a product. As a commodity reaches a mature stage, its further development becomes increasingly challenging. The product lifecycle reaches a critical turning point, sometimes referred to as the fault line, at this stage.

The time when a new technology supplants an established technology is referred to as the point of replacement. When two S-Curves overlap, it indicates that the firm has transitioned from one technology to another, marking the arrival of a new technology. Consequently, the introduction of a new technology has disrupted the product lifetime of the incumbent technology. Moore (2000) analyzes the concept of the fault line, as depicted in the S-Curve, within the framework of a production development's business model. The figure below illustrates the S-Curve of a product's business model. The second S-Curve illustrates the superior performance of the disruptive invention compared to the anticipated performance of the initial product. The S-Curve Framework for transformational Technologies highlights a critical juncture in the advancement of transformational technologies. The occurrence of the point of inflection is typically associated with the moment when a new technology supersedes an older technology. Many organizations struggle to anticipate whether a novel technology will cause disruption to an established technology or if it will instead replace the old technology as the dominant one. Businesses have the predicament of determining whether or not to allocate resources towards adopting nascent technology in order to sustain a competitive edge in the market.

Christensen (2000) asserts that the S Curve structure is a highly reliable indicator for managing long-term sustainable technology. However, there is a lack of historical data to substantiate the progression of disruptive technologies along the S-Curve in previous instances. Consequently, the information technology division is required to monitor the advancement of emerging technology as it progresses along the S-Curve of established technology. At the crucial juncture, the information technology business unit must be prepared and capable of reacting. Disruptive technology often emerges in the market without prior anticipation, as seen by the graph below that portrays the progressive triumph of disruptive technology over a period of time (Disruptive technology, 2007). Figure 3 illustrates the progressive advancement of transformational technologies over time, specifically in the context of the retail

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industry's lower segment. This depiction highlights the tendency to underestimate the actual potential and capabilities of these technologies. Once the lower end of the market adopts the disruptive technology, it undergoes modifications to enhance its attractiveness to the top end of the market. The upper echelon of the sector expects enhanced functionality of superior quality that can surpass the capabilities of current market technology. The cutting-edge technology has been enhanced to cater to the needs and preferences of consumers who are willing to spend a premium for a high-quality product. Disruptive technology can be replaced due to its provision of a more robust alternative compared to enduring technology, and consumers acknowledge the potential of disruptive technology (Christensen, 2000). Additional factors, such as the specific sector and prevailing patterns in information technology, influence the choice to embrace a new technology. This study will investigate the impact of developing technologies on enterprises.

CONCLUSION

Disruptive innovations have the capacity to be quickly accepted in emerging countries, therefore speeding up the adoption of technology and improving social well-being. A key obstacle that low-income nations continuously encounter is the limited spread of technology, which hinders their ability to improve their competitiveness. In the past, the ability of these nations to embrace and incorporate innovations was hindered by an adverse climatic condition. Contrarily, disruptive inventions have several attributes that might help overcome chronic limitations and initiate change in expanding markets. Both organizations and customers have concerns over the extensive implementation of new technologies and improvements to current business models. Ride-hailing companies in the transportation sector function without owning any tangible cars. Likewise, online retail businesses operate without physically storing any goods. Online lodging platforms provide lodgings without possessing any tangible assets, while social media companies implement steps to moderate content. Although the effects of transformative technology have been thoroughly studied in developing economies, where new technologies usually emerge, emerging markets face increased levels of uncertainty. While the second choice has more promise, technology still has the ability to exceed current institutions and create solutions that are more innovative than those observed in wealthy nations. This is apparent from the illustration of cell phones and electronic payments, which showcased this capacity more than ten years ago. IT administrators frequently employ the strategy of implementing extra technologies in order to tackle different challenges. Nevertheless, it is important to acknowledge that customer happiness cannot be attained exclusively via the acquisition of technology. Instead, it is crucial to synchronize the technology being utilized with the fundamental requirements and inclinations of persons. In addition, the company aggressively pursues the essential information without depending on the client to begin communication. IT firms must concentrate their focus on digital technologies and work processes that proactively detect and resolve gaps in customer experience. The ability to recognize and resolve these weaknesses before they become problems is crucial for ensuring a positive consumer experience and, ultimately, the level of support and satisfaction provided by the IT industry.

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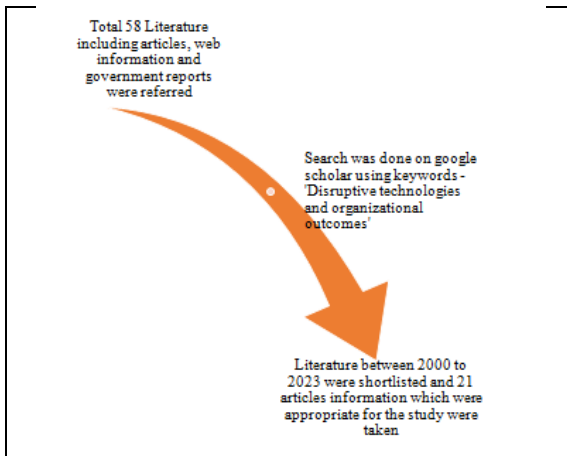


Figure 1: Sample size for the study

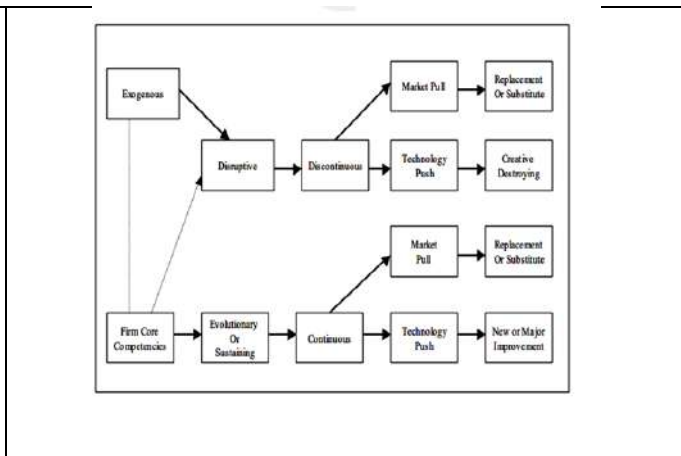


Figure 2: A model of transformative and enduring technology

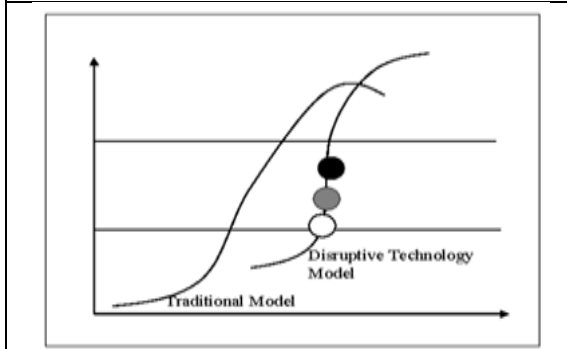


Figure 3: Model of disruptive technologies

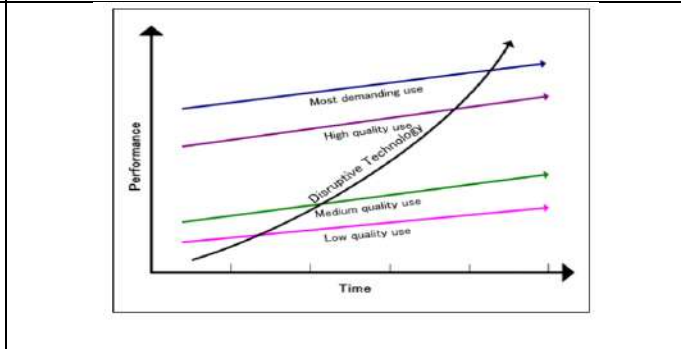


Figure 4 : Disruptive technology's performance over time





A Pilot Study to Assess Physical Fitness Variables and NCD Risk Factors among Physiotherapists

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ABSTRACT

Physiotherapists need good physical fitness for their job demands and are mostly prone to risk factors of non-communicable disease (NCD), which could harm their health and quality of life. We evaluated the physical fitness variables and risk factors of NCD among physiotherapists. This prospective cross-sectional pilot survey involved working physiotherapists in academic settings in Surat, Gujarat. We examined physical activity by examining cardio-respiratory fitness, flexibility, body composition, muscular endurance, and muscular strength, static balance and dynamic balance, and the prevalence of risk factors for NCD. Of 10 physiotherapists (mean age; 32.20 ± 6.68 years; female, 8), physiotherapists had average lower limb flexibility ($n=6$) and excellent upper limb flexibility ($n=8$) but showed very low upper-body muscular endurance (8.20 ± 10.30), and below-average trunk muscular endurance (12.70 ± 8.41). The dominant hand (24.60 ± 9.94 kg) displayed greater strength than the non-dominant hand (21.40 ± 8.30 kg). Physiotherapists also had elevated risk factors for NCD (obesity [BMI, 23.80 ± 3.94 Kg/m² and waist circumference, 83.20 ± 10.61 cm], prolonged sitting time (7.40 ± 1.76 hours per day), and low physical activity [physical activity MET value, 1864 ± 2280 min/week]). This study emphasizes inadequate physical fitness among physiotherapists, urging urgent policy interventions to combat prevalent risk factors of NCD and physical inactivity. Prioritizing lifestyle changes is critical to enhance physiotherapists' fitness.

Keywords: non-communicable disease, physical activity, physiotherapist, risk factor





INTRODUCTION

Physical fitness is integral to human health and overall well-being and encompasses various aspects, including flexibility, cardiovascular endurance, body composition, and muscular strength endurance [1-4]. Regular physical activity and maintaining health-related physical fitness are crucial markers of overall health outcomes [5, 6]. Physiotherapists acknowledge the significant impact of physical activity and exercise in their practice, recognizing them as fundamental contributors to health and mitigators of risks associated with conditions like diabetes, hypertension, and cardiovascular diseases [7-10]. However, recent research has highlighted instances of physical inactivity among physiotherapists [11-16]. It is paramount to encourage physical activity among physiotherapists to reduce the levels of physical inactivity and the consequent burden of non-communicable diseases (NCD) due to following two main reasons: 1) Physical fitness levels play a direct role in physiotherapists' capacity to provide effective care and function as role models for their patients and 2) Physiotherapists are prone to risk factors of NCD, which could negatively impact their personal health outcomes and quality of life. In lieu of this, the present pilot study aims to evaluate physical fitness variables and risk factors of NCD among physiotherapists.

METHODOLOGY

This prospective cross-sectional pilot survey was conducted among working physiotherapists in academic settings in Surat, Gujarat. Written permission was obtained from the Head of Institute of Physiotherapy College. Each participant was individually briefed about the study and invited to participate voluntarily after providing written informed consent. The study assessed various physical fitness parameters, including cardio-respiratory fitness (via the Queens College step test), flexibility (via YMCA sit-and-reach test and shoulder flexibility test), body composition (via body mass index), muscular endurance (via push-up and curl-up tests), and hand grip strength to determine muscular strength (via the Jamar Hand Dynamometer). Static balance was assessed using the unipedal stance test, while dynamic balance was assessed through the star excursion balance test (SEBT). Risk factors for NCD were assessed using the World Health Organization (WHO) STEPS Instrument (Steps I and II) in accordance with the guidelines outlined in the WHO STEPS manual. Data analysis was performed using Statistical Package for the Social Sciences, Version 22.0. Descriptive statistics are reported as mean \pm standard deviation (SD), median [interquartile range (IQR)] frequency and percentages. Pearson's correlation was used to measure linear correlation between two sets of data.

RESULTS

A total of 10 physiotherapists participated in this survey. The mean age of study population was 32.20 ± 6.68 years and predominantly comprised females ($n=8$). (Table 1). Data are presented as mean \pm standard deviation and upper and lower range. The lower limb flexibility grade and number of curl-ups were 15.75 ± 3.14 , and 12.70 ± 8.41 , respectively. The values for unipedal stance test with eyes open and closed were 39.60 ± 10.41 (16.00–45.00) and 15.30 ± 11.91 (5.00–41.00) seconds, respectively. We found symmetrical balance capabilities between the left and right lower limbs examined by SEBT, with some slight variations in specific directional reaches. Other physical parameters of the physiotherapists are described in Table 2.

Abbreviation

BMI, body mass index;

D, dominant; L, left;

LL, lower limb;

ND, non-dominant;

SEBT, star excursion balance test - science for sport;

R, right; VO_{2max} , maximal oxygen consumption



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Data are presented as mean \pm standard deviation and upper and lower range. As demonstrated in Table 3, majority of the participants had average lower limb flexibility grade (n=6), excellent upper limb flexibility grade (n=8), below average number of curl-up (n=4), below average push-up test score (n=4), below average unipedal stance test with closed and open eye (n=4), below average VO_{2max} (n=5), below average hand-grip strength (D) (n=4) and hand-grip strength (ND) (n=4).

Abbreviations

D, dominant;

LL, lower limb;

ND, non-dominant;

UL, upper limb;

VO_{2max} , maximal oxygen consumption

We have found positive correlation between age and VO_{2max} ($r=0.832$, $p=0.003$). In table 4, mean value for physical activity metabolic equivalent of task (MET) was 1864 ± 2280 min/week, and the median (IQR) physical activity MET was 1000 (400–1680) min/week. Other parameters are outlined in Table 4.

Abbreviations

BMI, body mass index;

NCD, non-communicable disease

Data are presented as mean \pm standard deviation and upper and lower range.

DISCUSSION

Physiotherapy demands high levels of physical activity and fitness due to professional requirements and the expectation of being fitness authorities in society [1]. In the present study, six physiotherapists demonstrated average lower limb flexibility and eight had excellent upper limb flexibility, assessed by the sit and reach test. This emphasizes physiotherapists' notable flexibility, potentially lowering the risk of musculoskeletal disorders. In contrast, Multani et al. [11] found over 50% of physiotherapy students had poor upper limb flexibility. Hence, there's a need to explore factors affecting shoulder flexibility. Consequently, there is a necessity to investigate the primary factors influencing shoulder flexibility. In accordance with Parkar et al. [12], physiotherapists in the study exhibited notably low upper-body muscular endurance, as evidenced by push-up test scores (8.20 ± 10.30). Additionally, physiotherapists had below-average trunk muscular endurance, as indicated by the number of curl-ups performed (12.70 ± 8.41). All the findings may be attributed to limited time for regular exercise. The present study reveals a notable disparity in grip strength between the dominant and non-dominant hands, with the dominant hand exhibiting greater strength (24.60 ± 9.94 kg) compared to the non-dominant hand (21.40 ± 8.30 kg), which is consistent with findings of Polina et al. [13]. The findings suggest the necessity of focusing on enhancing muscular strength, particularly in the non-dominant hand. The SEBT that evaluates the dynamic balance of the lower limbs [14], indicated generally symmetrical balance capabilities between the left and right lower limbs in the present study, with minor variations in specific directional reaches. This evaluation offers valuable insights into the individual's dynamic balance skills. In the present study, physiotherapists were found to have higher BMI and waist circumference, coupled with high daily sitting times and low levels of physical activity, indicating a need for urgent actions to promote physical activity and mitigate risk factors for NCD. The low physical activity observed among physiotherapists in our study emphasizes the importance of instilling a positive attitude towards physical fitness among physiotherapists, with the ultimate goal of achieving optimal fitness levels.



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CONCLUSION

The present study reveals that the physical fitness level of physiotherapists is unsatisfactory. Considering the elevated prevalence of NCD's risk factors within this group, urgent policy actions are necessary to mitigate these health concerns. It is crucial to improve physiotherapists' fitness levels through lifestyle adjustments.

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Table 1: Demographic data of physiotherapist

Parameters	Physiotherapists (N=10)
Age group (years)	
24–30	6
>30	4
Age (years)	32.20 ± 6.680 (24–43)
Gender	
Female	8
Male	2
Education	
Bachelor of physiotherapy	3
Master of physiotherapy (cardiology)	2
Master of physiotherapy (neurology)	2
Master of physiotherapy (orthopedic)	2
Master of physiotherapy (women’s health)	1
Occupation	
Academic	10
Experience in the field of physiotherapy (years)	
< 10	6
≥ 10	4
Predominant field of working	
Teaching, administrative	1
Teaching, clinical teaching	1
Teaching, computer work	1
Teaching, treating orthopedic patients	4
Treating orthopedic patients	1
Treating patients -neurology and orthopedic	2

Table 2: Physical fitness parameters of physiotherapists

Parameters	Physiotherapists (N=10)
Lower limb flexibility grade	15.75 ± 3.14 (10.00–19.00)
Number of curl-up	12.70 ± 8.41 (0.00–25.00)
Push-up test score	8.20 ± 10.30 (0.00–35.00)
Unipedal stance test with eyes open (seconds)	39.60 ± 10.41 (16.00–45.00)
Unipedal stance test with eyes closed (seconds)	15.30 ± 11.91 (5.00–41.00)





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VO _{2(max)} , mL/kg/min	37.97 ± 5.66 (31.09–48.33)
Hand-grip strength(D), Kg	24.60 ± 9.94 (12.00–45.00)
Hand-grip strength(ND), Kg	21.40 ± 8.30 (11.00–38.00)
SEBT anterior L	93.58 ± 12.76 (68.88–110.96)
SEBT anterior R	92.32 ± 12.26 (67.77–107.00)
SEBT antero-lateral L	101.90 ± 17.21 (69.25 –136.00)
SEBT antero-lateral R	101.93 ± 12.19 (76.29 –117.00)
SEBT lateral L	95.01 ± 13.12 (72.96–121.05)
SEBT lateral R	97.65 ± 11.44 (75.18–114.10)
SEBT postero-lateral L	96.34 ± 13.38 (73.70–125.00)
SEBT postero-lateral R	98.22 ± 9.91 (77.40–114.91)
SEBT posterior L	88.55 ± 14.04 (62.22–118.42)
SEBT posterior R	86.91 ± 15.82 (62.22–110.43)
SEBT postero-medial L	77.53 ± 12.75 (48.88–93.60)
SEBT postero-medial R	82.56 ± 15.36 (51.11–98.83)
SEBT medial L	71.87 ± 10.98 (48.51–82.06)
SEBT medial R	70.33 ± 11.07 (52.22–84.10)
SEBT antero-medial L	85.04 ± 11.67 (62.96–95.34)
SEBT antero-medial R	86.00 ± 11.08 (67.75–102.99)

Table 3: Grading of physical fitness parameter

Parameters	Grade	Physiotherapists (N=10)
Lower limb flexibility grade	Above average	1
	Average	6
	Below average	1
	Well below Average	2
Upper limb flexibility grade	Average	1
	Excellent	8
	Poor	1
Number of curl-up	Fair	1





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	Average	1
	Below average	4
	Well below average	4
Push-up test score	Fair	1
	Average	1
	Below average	4
	Well below average	4
Hand-grip strength (D) (Kg)	Fair	1
	Average	1
	Below average	4
	Well below average	4
Hand-grip strength (ND) (Kg)	Fair	1
	Average	1
	Below average	4
	Well below average	4

Table 4: Mean levels of risk factors for NCD

Risk factors for NCD	Physiotherapists (N=10)
Systolic blood pressure, mmHg	111.00 ± 10.72 (98.00 ± 128.00)
Diastolic blood pressure, mmHg	70.40 ± 5.32 (62.00–76.00)
Heart rate, mmHg	77.00 ± 6.86 (65.00–87.00)
Waist circumference, cm	83.20 ± 10.61 (72.00–104.00)
Hip circumference, cm	100.00 ± 9.71 (91.00–126.00)
BMI, kg/m ²	23.80 ± 3.94 (17.87–32.92)
Physical activity metabolic equivalent of task, min/week	1864 ± 2280
Salt (sodium chloride) intake, g/day	
Always	1
Often	3
Rarely	2
Sometimes	4
Frequency of junk food consumption, days/month	3.90 ± 1.79 (1.00–7.00)
Sitting time per day, hours	7.40 ± 1.76 (5.00–10.00)





Inducing Systemic Resistance in Groundnut (*Arachis hypogaea* L.) by Combined Application of Bioinoculants Fortified with Humic Acid against *Macrophomina phaseolina* (Tassi) Goid

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ABSTRACT

Soil-borne pathogens were taken into consideration as hazard to agriculture resulting in high yield losses. *Macrophomina phaseolina* (Tassi) Goidis, one of the important soil borne pathogen causing root rot of groundnut prevalent in all growing area worldwide. Owing to the longer survivability of this saprophytic fungus, its control is difficult. Biological control is the most effective component for providing long-term solution for controlling plant diseases. The present study was undertaken to find out the efficacy of bioinoculants such as *Streptomyces*, *Rhizobium* and *Bacillus* alone and in combined effect of bioinoculants fortified with humic acid against root rot incidences. The groundnut plants are treated with combined application of *Streptomyces albobacillus*, *B. japonicum* and *Bacillus subtilis* fortified with humic acid as seed treatment @ 10g/kg of seeds plus soil application @ 2.5 kg ha⁻¹ (T₆) recorded minimum diseases incidence and significantly enhanced the yield parameters. A decrease in disease occurrence and severity may be due to the induced resistance imparted by the bioinoculants. This resulted in significant increments in quantities of defense enzymes, including catalase, peroxidase (PO), Polyphenol oxidase (PPO), Phenylalanine ammonia lyase (PAL) and β -1, 3 Glucanase activity. Thus, bioinoculants can be employed for the production of a potential formulation to support sustainable agriculture by reducing the input of synthetic pesticides and fertilizers.

Keywords: Groundnut, *Macrophomina phaseolina*, bioinoculants fortified with humic acid, induction of defense enzyme.





INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important edible oil seed crop grown extensively in tropical and sub-tropical regions of the world and also considered as “king of oil seed crops” or “wonder nut” or “poor man’s cashew nut”. It is fourth most important source of edible oil and third most important source of vegetable protein as the kernels are rich in 40 to 50 per cent of oil, 25 to 30 per cent of protein, 18 per cent of carbohydrates, minerals (P, Ca, Mg and Fe), antioxidants and vitamins (B1, B2 and niacin). India ranks first position in terms of area with 5.75 million hectares, with production of 10.11 million tones and productivity is 1759 kg/ha. (DOES-MOAFW, 2022). In India, the major growing states are Gujarat, Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra, Madhya Pradesh, Rajasthan. In Tamil Nadu groundnut is grown in 0.37 million hectares, with production of 0.95 million tones and productivity is 2553 kg/ha. (DOES-MOAFW, 2022). Groundnut production is decreasing gradually because of various biotic and abiotic stresses. Biotic stresses such as fungal, bacterial, and viral diseases play a major role in yield reduction. The soilborne diseases caused by fungal pathogens are very important, and several of them have the potential to cause significant yield losses in groundnut production (Pandey *et al.*, 2021). The *Macrophomina phaseolina* is an important pathogen that causes dry root disease (Chakrabarty *et al.*, 2005); it is distributed globally, and groundnut crops at all stages are susceptible to infection. The average yield loss caused due to root rot incidence is 25%. But in severe cases it reaches up to 80-90% (Moradia and Khandar *R*, 2011). Chemical-based management of *M. phaseolina* is not practicable owing to high cost besides causing environmental pollution and development of resistance to target fungus (Backman, 1997). Biological control is the best alternative, especially against soil-borne pathogens (Hibaret *et al.*, 2007; Sreeramuluet *et al.*, 2009). Among the various antagonists, bioinoculants such as *Streptomyces*, *Rhizobium* and *Bacillus*, plays a vital role in reducing the population of *Macrophomina phaseolina*. Bioinoculants exhibited different mode of actions such as competition, parasitism, antibiosis, lysis and Induced Systemic Resistance. Among them defense related enzymes plays a major role in boosting the immunity of host plants and make the resistance to different plant parasitic pathogens.

MATERIALS METHODS

Preparation of talc-based formulation of bioinoculants and fortification with humic acid

Virulent bacterial bioinoculants (*Streptomyces* spp, *Rhizobium*, spp, *Bacillus* spp) were grown in Ken knight & Munaier’s broth, YEMA broth and NA broth respectively @ 28 ± 2° C for 48 hours. One Kilo grams of carrier material (Talc powder) was taken and the pH was adjusted to 7 by adding CaCO₃ at the rate of 15g/kg. Carboxy methyl cellulose (CMC) was then added at the rate of 10g/kg and mixed well. The mixtures were then autoclaved for 30 min at 121°C (15lb/inch²). After autoclaving, 400 ml of bioinoculants suspension (1×10⁸cfu/ml) was added to the sterilized carrier material (1kg) and thoroughly mixed followed by drying aseptically and then grounded to powder. Humic acid powder has been obtained from ARVEEBIOTECH, Chidambaram. The talc-based formulation of bioinoculants were mixed with Humic acid powder @100g/ kg then packed in sterile polythene bags and stored at 4°C (Vidhyasekaran and Muthamilan, 1995).

The concentration of colony-forming units was obtained using the formula

$$\text{Number of cfu/g} = \frac{\text{Number of colonies}}{\text{Amount of sample plated} \times \text{Dilution}} \times 100$$

Pot culture experiment

A pot culture study was conducted to test the efficacy of antagonists bioinoculants fortified with humic acid against root rot of groundnut. The sterilized garden land soil is collected and filled in plastic pots of size 25 x 22x 15 cm with 25 kg and TMV-7 seeds were used for this study. The trial was conducted in completely randomized block design with nine treatments and three replications each at Department of Plant Pathology, Annamalai University, Annamalai Nagar from October 2022 to March 2023. The plants in the pots have been maintained with uniform, regular and judicious watering. The individual and combined application of bioinoculants *Viz*, *Streptomyces albobaciens*, *Bradyrhizobium japonium*, *Bacillus subtilis*, fortified with Humic acid (HA) and chemical Nativo 75 WP@ 1g/Kg of seeds



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were tested against *Macrophominaphaseolina*. Mass multiplication of *Macrophominaphaseolina* is grown in sand maize medium and 20 days old culture were inoculated in 30 days old plants. The inoculated plants were incubated in a humid chamber for 48 h and subsequently moved to the greenhouse and it is maintained at 22-28°C, 70-90% relative humidity. Under a light intensity of 85 $\mu\text{mol m}^{-1} \text{S}^{-1}$, 12 h photoperiod and subsequently transfer to pot culture yard.

Treatment schedule

T1- Seed treatment of *Streptomycesalbofaciens* @ 10 g/kg of seed + Soil application of *Streptomycesalbofaciens* @ 50g/ pot on TOS, T2- Seed treatment with *B.japonicum* at @ 10 g/ kg of seed + Soil application of *B.japonicum* @ 50 g /pot on TOS, T3- Seed treatment of *Bacillus subtilis* @ 10g/kg of seeds + Soil application of *Bacillus subtilis* @ 50g/ pot on TOS+, T4 - T1+ T2, T5 - T3 + T4, T6 - T5 + Fortification with humic acid@ 100g/ kgof bio inoculant as soil application on TOS , T7 - Seed treatment with Nativo 75 WP @ 1g/Kg of seeds, T8- Healthy control, T9- Inoculated control .

Assessment of the disease severity in the field

Twelve plants from each plot were randomly selected and tagged for grading the severity of diseases. The severity of *Macrophominaphaseolina* was measured as per the standard evaluation system (SES) for groundnut. The disease severity was recorded at 30,60,90DAS and at the time of harvest and per cent diseases index was determined us usual.

Field trial

The field trials were conducted at Komaratchi, Cuddalore district of Tamil Nadu during May 2023 to August 2023, in field with a history of Root rot incidence. The trial was laid out in plots (5x4 m) arranged in randomized block design. Groundnut seeds of cv. TMV-7 were sown in row/ plant spacing of 30 x 10 cm. Three replicate plots were maintained for each treatment. Regular cultivation practices have been accompanied as according to the recommendation. Treatment application details and experimental observation were the same as in greenhouse experiment.

Treatment schedule

T1- Seed treatment of *Streptomycesalbofaciens* @ 10 g/kg of seed + Soil application of *Streptomycesalbofaciens* @ 2.5 kg ha^{-1} on TOS, T2 -Seed treatment with *B. japonicum* at @ 10 g/ kg of seed + Soil application of *B. japonicum* @ 2.5 kg ha^{-1} on TOS , T3- Seed treatment with *Bacillus subtilis* @ 10g/kg of seeds + Soil application of *Bacillus subtilis* @ 2.5 kg ha^{-1} on TOS , T4 - T1+ T2, T5 -T3 + T4, T6 - T5 +Fortification with humic acid @ 100g/ kg of bio inoculant as soil application on TOS, T7 - Seed treatment with Nativo 75 WP @ 1g/kg of seeds , T8- Untreated control.

Data analysis

The data obtained from the studies conducted under laboratory and field conditions were subjected to the analysis of variance techniques (ANOVA) and were applied to completely randomized design (CRD) and randomized block design (RBD). The data obtained on per cent inhibition were transformed using angular (arc sine) transformation.

Estimation of induction defence enzyme:

Pot culture study was conducted to estimation of induction defence enzyme by combined application of bioinoculants fortified with humic acid against challenge inoculation of *Macrophominaphaseolina* with following treatments, T1- Seed treatment of *Streptomycesalbofaciens* @ 10 g/kg of seed + Soil application of *Streptomycesalbofaciens* @ 50g/ pot on TOS, T2- Seed treatment with *B.japonicum* at @ 10 g/ kg of seed + Soil application of *B.japonicum* @ 50 g /pot on TOS, T3- Seed treatment of *Bacillus subtilis* @ 10g/kg of seeds + Soil application of *Bacillus subtilis* @ 50g/ pot on TOS, T4 - T1+ T2, T5 - T3 + T4, T6 - T5 + Fortification with humic acid @ 100g/ kg of bioinoculants, T7 - Seed treatment with Nativo 75 WP @ 1g/Kg of seeds, T8- Healthy control, T9- Inoculated control. Plants are inoculated with pathogen on 30th days after sowing and estimated the defence on various treatment on 0,3,5,7 and 9 days intervals from the inoculation of pathogen.



**Evanjalin and John Christopher****Enzyme extraction**

One g of root sample was homogenized with 2 ml of 0.1M sodium citrate buffer (pH 5.0) at 4°C. The homogenate was centrifuged for 20 min. at 10,000 rpm. Enzyme extracted in 0.1 M sodium phosphate buffer (pH 7.0) was used for the estimation of Peroxidase (PO), Polyphenol Oxidase (PPO), Phenylalanine Ammonia Lyase (PAL) and β -1, 3-glucanase. Enzyme extract was stored in deep freezer (-70° C) until used for biochemical analysis.

Peroxidase (PO)

Peroxidase activity was assayed as per the procedure described by Hammerschmidt *et al* (1982). In a pre-cooled pestle and mortar, one gram of fresh leaf tissue was mashed using one ml of 0.1M phosphate buffer at pH 7.0. The homogenate was centrifuged at 15000 rpm at 4°C for 15 minutes. The supernatant was served as a source of enzyme. About 1.5 ml 0.05M pyrogallol, 0.5 ml of one per cent H₂O₂ and 0.1 ml of enzyme extract was used for preparation reaction mixture. The reaction mixture absorbance was measured at 420 nm for every 30 seconds up to 3 minutes at room temperature (28 ±2°C). The boiled enzyme preparation served as blank. The enzyme activity was measured as a change in the reaction mixture's absorbance min⁻¹g⁻¹ of the leaf.

Poly phenol oxidase (PPO)

PPO activity was determined as per the procedure given by Mayer *et al.* (1965). One gram of fresh leaf sample was ground in one ml of 0.1M sodium phosphate buffer, (pH 6.5). The homogenate was centrifuged at 15000 rpm in 4 °C for 15 minutes, and the supernatant was employed as an enzyme source. About 1.5 ml of 0.1 M sodium phosphate buffer (pH 6.5) and 0.1 ml of enzyme extract was used to make up the reaction mixture. After adding 0.2 ml of catechol (0.01 M) to the mixture, the reaction was started. The activity was measured as a change in absorbance at 495 nm from every 30 second intervals for three minutes, and measured the enzyme activities in terms of the change in absorbance min⁻¹g⁻¹ of fresh tissue.

Phenylalanine ammonia-lyase (PAL)

The PAL activity was assayed as per the method described by Ross and Sedroff (1992). For phenylalanine ammonia lyase assay (PAL), about five ml of cold 25mM Borate HCL buffer (pH 8.8) containing 5mM mercaptoethanol (0.4 ml per litre) was used to homogenize the 500 mg of plant leaves. The homogenate was centrifuged at 15000 rpm for 15 minutes and the supernatant served as an enzyme source. About 0.2 ml of enzyme extract, 1.3 ml of water and 0.5 ml of borate buffer used to make up the reaction mixture. About one ml of 12mM L-Phenylalanine was added and initiated the reaction. The reaction mixture was incubated for one hour at 32°C. The reaction was stopped with the addition of 0.5 ml of 2N HCL. The 2N HCL and phenylalanine was added after the blank run. The absorbance was measured at 290 nm. The enzyme activity was expressed as nmoles of cinnamic acid Min⁻¹g⁻¹ of fresh tissue.

 β -1, 3-glucanase

β -1, 3-glucanase activity was assayed with the aid of using laminarin-dinitrosalicylic acid method (Pan *et al.*, 1991). The reaction was carried out at 40° C for 10 min. The reaction was then stopped via by means of adding 375 μ l of dinitrosalicylic acid and heated for five min in boiling water. Vortexed and the absorbance was measured at 500nm. The enzyme activity was expressed as μ g glucose released Min⁻¹g⁻¹ fresh tissue.

RESULTS

Efficacy of combined application of *Streptomyces albobifaciens*, *B. japonicum* and *Bacillus subtilis* plus fortification with humic acid against dry root rot of groundnut

Pot culture condition

The pot culture experiment was carried out to evaluate the efficacy of combined application of bioinoculants fortified with Humic acid (HA) against root rot incidence of groundnut. The result revealed that all the bioinoculants were





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found to be effective in inhibiting the progress of disease development than the untreated control (Table I). Among the various treatments, combined application of *Streptomyces albobifaciens*, *B. japonicum* and *Bacillus subtilis* plus fortification with humic acid @ 100g/ kg of bioinoculants as seed treatment @ 10 g/kg of seed and soil application @ 100g/ pot (T6) recorded minimum root rot disease incidence which recorded 4.12%, 5.70%, 8.52% and 9.05% percent disease incidence on 30, 60, 90 and At the time of harvest respectively, it was followed by the combined application of *Streptomyces albobifaciens*, *B. japonicum* and *Bacillus subtilis* as seed treatment @ 10 g/kg of seed and soil application @ 50g/ pot (T5) recording the root rot incidence of 6.02% ,8.51%, 11.01% and 11.30% percent disease incidence on 30,60, 90 DAS, and at the time of harvest respectively and standard chemical check Nativo 75 WP @ 1g/kg of seeds (T7) registered the root rot disease incidence of 7.34%, 8.96%, 11.69% and 12.96% percent disease incidence on 30, 60, 90 DAS and at the time of harvest respectively. All the bioinoculants treated plants significantly reduced the disease incidence as compared to control. Combined application of bioinoculants has reduced the disease incidence than the individual application of bioinoculants. The combined application of *Streptomyces albobifaciens*, *B. japonicum* and *Bacillus subtilis* plus fortification with humic acid @ 100g/ kg of bioinoculants as seed treatment @ 10 g/kg of seed and soil application @ 100g/ pot (T6) significantly reduced the disease incidence of dry root rot of groundnut than all other treatments including standard chemical check and also significantly increased the yield than other treatments, which recorded maximum biomass (30.72g/plant) and pod yield (64.79g/plant).

Field trial

The same trend as pot culture was observed in field trial also. The minimum disease incidence was registered with combined application of *Streptomyces albobifaciens*, *B. japonicum* and *Bacillus subtilis* plus fortification with humic acid @ 100g/ kg of bioinoculants as seed treatment @ 10 g/kg of seed and soil application @ 2.5 kg ha⁻¹ of each (T6) recorded minimum root rot disease incidence, which recorded 4.13%, 6.94%, 9.54% and 8.25% percent disease incidence on 30, 60, 90 and at the time of harvest respectively and followed by the combined application of *Streptomyces albobifaciens*, *B. japonicum* and *Bacillus subtilis* as seed treatment @ 10 g/kg of seed and soil application @ 2.5 kg/ ha of each (T5) recording the root rot incidence of 4.96 % ,8.84 % , 12.73% and 14.65% percent disease incidence on 30,60, 90 DAS and at the time of harvest respectively and plants are treated with standard chemical check Nativo 75 WP as @ 1g/kg of seeds (T7) registered the root rot disease incidence of 5.32%, 7.14%, 13.69% and 15.41% percent disease incidence on 30, 60, 90 DAS and at the time of harvest respectively. Combined application of bioinoculants fortified with humic acid has reduced the disease incidence than the individual application of bioinoculants and standard chemical check. The combined application of *Streptomyces albobifaciens*, *B. japonicum* and *Bacillus subtilis* plus fortification with humic acid @ 100g/ kg of bioinoculants as seed treatment @ 10 g/kg of seed and soil application @ 2.5kg/ha of each (T6) significantly reduced the disease incidence of dry root rot of groundnut than all other treatments including standard chemical check and also significantly increased the yield than other treatments, which recorded maximum No of pods (40.42g/plant) and pod yield (1801 kg/ha). (Table II)

Induction of defence enzymes in groundnut due to combined application of *Streptomyces albobifaciens*, *B. japonicum* and *Bacillus subtilis* plus fortification with humic acid against challenge inoculation of pathogen.

The induction of defence enzymes viz., peroxidase (PO), polyphenol oxidase (PPO), Phenylalanine ammonia lyase (PAL) and β -1, 3 Glucanase in groundnut plant due to combined application of bioinoculants fortified with Humic acid against challenge inoculation with pathogen was estimated. Plants are treated with bioinoculants viz., *Streptomyces albobifaciens*, *B. japonicum* and *Bacillus subtilis* were significantly induce the defense enzymes than the control (Table III). Among the treatments maximum induction of PO (1.73 changes in absorbance / min/ g of units), PPO (1.38 changes in absorbance / min/ g of units), PAL (74.56 μ mol of transcinamic acid/min/g of leaf tissue) and β -1, 3 Glucanase activity (73.5 μ g of glucose released / min/ g of unit) were observed with the combined application of *Streptomyces albobifaciens*, *B. japonicum* and *Bacillus subtilis* plus fortification with humic acid @ 100g/ kg of bioinoculants as seed treatment @ 10 g/kg of seed and soil application @ 100g/ pot against challenged inoculated with *Macrophomina phaseolina* (T6). This was followed by the combined application of *Streptomyces albobifaciens*, *B. japonicum* and *Bacillus subtilis* as seed treatment @ 10 g/kg of seed and soil application @ 50g/ pot (T5) recorded with PO (1.4773 changes in absorbance / min/ g of units), PPO (1.07 changes in absorbance / min/ g of units), PAL (55.33 μ mol of transcinamic acid/min/g of leaf tissue) and β -1, 3 Glucanase activity (63.3 μ g of glucose released / min/ g of



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unit) and plants treated with standard chemical check Nativo 75 WP as @ 1g/kg of seeds (T7). The groundnut plants inoculated with the pathogen alone recorded an increase in the activity of PO (1.89 changes in absorbance / min/ g of units), PPO (0.98 changes in absorbance / min/ g of units), PAL (12.90 μ mol of transcinamic acid/min/g of leaf tissue) and β -1, 3-Glucanase (11.64 μ g of glucose released / min/ g of unit) than the groundnut plants either treated with pathogen or treated with bioinoculants. The induction of PO, PPO, PAL and β -1, 3- Glucanase gradually increases up to fifth day of pathogen inoculation and thereafter decline slowly.

DISCUSSIONS

The efficacy of individual application of bioinoculants (*Streptomyces albobacis*, *Bradyrhizobium japonicum*, *Bacillus subtilis*) and in combination along with fortification of humic acid were tested against root rot disease of groundnut under pot culture and field condition. Plants treated with combined application of *Streptomyces albobacis*, *B. japonicum* and *Bacillus subtilis* plus fortification with humic acid @ 100g/ kg of bioinoculants as seed treatment @ 10 g/kg of seed and soil application @ 2.5 kg ha⁻¹ of each was found to significantly manage the root rot disease and in influencing the yield parameters. Similar findings were made by several workers using the bioinoculants of *Streptomyces*, *Rhizobium* and *Bacillus sp.* Seed treatment alone with powder formulation of *Streptomyces* sp. strains, CBE, MDU and PDK, was effective in controlling root rot disease; but, combined application through seed and soil increased the efficacy (Adhilakshmi *et al.* 2013). Al-Ani R.A *et al.* (2012) reported that the *Rhizobium japonicum*, an environmentally friendly alternative to fungicides was able to protect soybean plants against soil-borne pathogens (*F. solani* and *M. phaseolina*) and improve growth and yield. Neetu Singh *et al.* (2008) reported that *B. subtilis* BN1 showed a strong inhibitory effect on hyphal growth of *M. phaseolina*. Bioinoculants are fortified with Humic acid significantly enhancing the efficacy against pathogen and also enhance yield parameters than the bioinoculants alone. The result are accorded with Ranjinder Kaur *et al.* (2021), who reported that Humic acid and its derivatives promote the population of bioinoculants and enhance their excellent survival and root colonization. Similarly, plants are treated with combined application of *Streptomyces albobacis*, *B. japonicum* and *Bacillus subtilis* plus fortification with humic acid against challenge inoculation of pathogen maximum induced the defense enzymes viz., Peroxidase (PO), Polyphenol oxidase (PPO), Phenylalanine ammonia lyase (PAL), and β -1, 3-glucanase enzymes in groundnut.

Several authors have reported the maximum induction of defense enzymes in crop plants due to application of bioinoculants. Adhilakshmi *et al.* (2013) also found that the increased PO activity in mung bean plants treated with *Streptomyces sp.* might be involved in lignin biosynthesis, which in turn might have contributed to the resistance against *M. phaseolina*. Umar Khalid *et al.* (2024) has studied that *B. japonicum*-406 leads to the induction of defense enzyme in soybean plants. The highest increase was estimated in polyphenol oxidases. Kamalakannan (2004) reported the increased activity of PAL, PO, PPO and total phenolics in the bioagents (*Bacillus subtilis*) pretreated peppermint plants challenged with *R. solani*. ISR mediated through bio-control agents resulted on lignification and with increased activities of defense gene products that synthesized via phenyl propanoid pathway (Boller and Mauch, 1988; Kloepper *et al.*, 2004), which is known to oxidize phenols to o-quinones, leading to the formation of melanin. Polyphenol oxidases is responsible for lignification, cross-linking of phenolics and glycoproteins, suberization, phytoalexin production and initiation of hypersensitive response (Wojtaszek, P1997). Phenylalanine ammonia lyase (PAL) plays an important role in the biosynthesis of various defense chemicals in phenyl propanoid metabolism (Daay *et al.* 1997). Mauch and Staechelin (1989) reported that β -1,3-glucanase enzyme solubilises elicitor active glucan molecules from fungal cell walls. Biocontrol agents have a direct antagonistic activity not only by producing various metabolites, but also by inducing defense enzymes, which have recently been found to be a new way whereby plants defend themselves from pathogen attack (Bharathi *et al.*, 2004).





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CONCLUSION

The results reported here indicated that groundnut crop treated with combined application of *Streptomyces albobifaciens*, *B. japonicum* and *Bacillus subtilis* plus fortification with humic acid represents an ecofriendly strategy of managing *M. phaseolina* in groundnut plants and also promoted plant growth. Mixture of bioinoculants also have the advantage of exercising a broad-spectrum activity, enhancing the efficacy, reliability and ensuring greater induction of defence enzymes over the individual strain.

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Table 1. Combined effect of bioinoculants fortified with humic acid against dry root rot of groundnut incited by *Macrophominaphaseolina* in pot

Name of the treatments	Disease incidence (%)							Growth parameters		
	30 DAS	Percent disease reduction over control	60 DAS	Percent disease reduction over control	90 DAS	Percent disease reduction over control	At the time of harvest	Percent disease reduction over control	Biom ass (g/plant)	Pod Yield (g/plant)
T1	8.12 (16.55)	73.16	10.67 (19.06)	69.80	13.67 (21.69)	67.89	15.46 (23.15)	71.34	24.58	51.78
T2	9.56 (18.01)	68.40	12.83 (20.98)	63.69	15.35 (23.06)	68.12	16.89 (24.26)	68.69	23.71	48.64
T3	10.23 (18.65)	66.19	14.59 (22.45)	58.71	18.20 (25.29)	62.20	19.23 (26.09)	64.35	21.45	43.75
T4	7.63 (16.03)	74.78	9.20 (17.65)	73.96	12.25 (20.48)	74.58	13.69 (21.71)	74.62	27.19	57.23
T5	6.02 (14.20)	80.10	8.51 (16.96)	75.91	11.01 (19.37)	77.13	11.30 (19.64)	79.05	28.95	60.37
T6	4.12 (11.71)	86.38	5.70 (13.81)	83.87	8.52 (16.97)	82.30	9.05 (17.50)	83.22	30.72	64.79





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T7	7.03 (15.37)	75.74	8.96 (17.41)	74.90	11.69 (19.99)	75.72	12.96 (21.10)	75.97	29.76	42.87
T8	30.26 (33.37)		35.34 (36.47)		48.15 (43.93)		53.95 (47.26)			
T9	16.35 (23.85)		20.16 (26.67)		27.86 (31.85)		29.01 (32.58)			
C.D. at 5 %	0.70		0.84		1.14		1.24			
S. Em. ±	0.23		0.28		0.37		0.41			

T1- Seed treatment of *Streptomycesalbofaciens* @ 10 g/kg of seed + Soil application of *Streptomycesalbofaciens* @ 50g/ pot on TOS, T2- Seed treatment with *B.japonicum* at @ 10 g/ kg of seed + Soil application of *B.japonicum* @ 50 g /pot on TOS, T3- Seed treatment of *Bacillus subtilis* @ 10g/kg of seeds + soil application of *Bacillus subtilis* @ 50g/ pot on TOS, T4 - T1+ T2, T5 - T3 + T4, T6 - T5 + Fortification with humic acid @ 100g/ kg of bioinoculants as soil application @ 100g/pot on TOS, T7 - Seed treatment with Nativo 75 WP @ 1g/Kg of seeds, T8-Inoculated control, T9-.Healthy control.

Table 2. Combined effect of bioinoculants fortified with Humic acid against dry root rot of groundnut incited by *Macrophominaphaseolin* in field conditions

Name of the treatments	Disease incidence (%)							Growth parameters		
	30 DAS	Percent disease reduction over control	60 DAS	Percent disease reduction over control	90 DAS	Percent disease reduction over control	At the time of harvest	Percent disease reduction over control	No of pods/ plant	Pod Yield (kg/ha)
T1	6.97 (15.30)	64.85	13.37 (21.44)	53.07	15.49 (23.17)	53.44	17.51 (24.73)	52.36	35.49	1654
T2	7.14 (15.49)	63.99	14.35 (22.26)	49.63	17.34 (24.60)	47.88	19.62 (26.29)	46.62	31.35	1549
T3	8.67 (17.12)	56.27	15.28 (23.01)	46.36	18.57 (25.52)	44.18	21.17 (27.39)	42.41	27.67	1443
T4	5.83 (13.97)	70.60	10.59 (18.99)	62.82	14.27 (22.19)	57.10	17.89 (25.02)	51.33	39.05	1673
T5	4.96 (12.86)	74.98	8.84 (17.29)	68.97	12.73 (20.90)	61.73	14.65 (22.50)	60.14	41.50	1756
T6	4.13 (11.72)	79.17	6.94 (15.27)	75.64	9.54 (17.99)	71.32	8.25 (16.69)	77.55	49.04	1801
T7	5.32 (13.33)	73.17	7.14 (15.49)	74.38	13.69 (21.71)	58.85	15.41 (23.11)	58.79	33.70	1695
T8	19.83 (26.44)		28.49 (32.25)		33.27 (35.22)		36.76 (37.32)		25.90	937
C.D. at 5 %	0.45		0.68		0.82		0.94			
S. Em. ±	0.14		0.22		0.26		0.38			

T1- Seed treatment of *Streptomycesalbofaciens* @ 10 g/kg of seed + Soil application of *Streptomycesalbofaciens* @ 2.5 kg ha⁻¹ on TOS , T2 - Seed treatment with *B .japonicum* at @ 10 g/ kg of seed + Soil application of *B .japonicum* @ 2.5kg ha⁻¹ on TOS , T3- Seed treatment with *Bacillus subtilis* @ 10g/kg of seeds + Soil application of *Bacillus subtilis* @ 2.5 kg ha⁻¹ on TOS , T4 - T1+ T2, T5 -T3 + T4, T6 - T5 + Fortification humic acid @ 100g/ kg of bioinoculants as soil application on TOS, T7 - Seed treatment with Nativo 75 WP @ 1g/kg of seeds , T8- Untreated control.





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Table 3. Induction of defence enzymes in groundnut due to combined application of *Streptomycesalbofaciens*, *B. japonicum* and *Bacillus subtilis* plus fortification with humic acid against challenge inoculation of pathogen

Treatments	PO activity in plants Time interval (days)					PPO activity in plants Time interval (days)					PAL activity in plants Time interval (days)					β- 1, 3 glucanase activity in plants Time interval (days)				
	0	3	5	7	9	0	3	5	7	9	0	3	5	7	9	0	3	5	7	9
T1	1.19	1.35	1.40	1.09	0.95	0.86	0.90	0.94	0.54	0.53	64.54	66.22	70.32	40.89	29.36	33.5	42.8	50.5	63.9	55.8
T2	1.08	1.05	1.07	0.93	0.87	0.81	1.06	1.19	1.16	1.10	58.87	61.52	63.65	35.98	25.78	33.0	40.7	48.5	60.6	53.4
T3	0.92	0.94	0.96	0.69	0.75	0.74	0.79	0.81	0.42	0.37	49.25	52.12	55.19	29.54	22.32	32.0	40.6	48.4	60.5	53.3
T4	1.38	1.41	1.45	1.21	0.96	1.12	1.14	1.22	0.85	0.71	66.58	69.25	72.22	55.55	35.27	34.0	44.5	52.1	64.6	57.5
T5	1.96	2.10	2.41	1.83	0.99	1.41	1.44	1.55	1.03	1.07	77.19	85.25	91.64	68.23	55.33	35.0	49.2	55.3	72.4	69.3
T6	2.10	2.33	2.82	1.97	1.10	1.73	1.94	2.46	1.76	1.38	85.23	88.89	94.46	74.56	61.36	36.8	53.6	59.7	76.7	73.5
T7	1.75	2.01	2.25	2.20	1.89	1.23	1.25	1.31	0.98	0.96	73.65	78.41	85.44	61.57	39.28	34.5	47.0	53.6	65.5	59.0
T8-	0.49	0.53	0.58	0.44	0.32	0.33	0.40	0.46	0.19	0.16	11.32	12.43	13.20	12.90	12.85	10.02	11.75	12.01	11.64	11.50
T9	0.60	0.63	0.67	0.50	0.39	0.44	0.49	0.55	0.27	0.20	31.22	33.97	36.09	25.19	18.27	30.1	34.9	34.9	35.35	34.8
C.D. at 5%	0.05	0.06	0.07	0.06	0.06	0.04	0.04	0.05	0.04	0.03	2.47	2.60	2.80	1.99	1.32	1.32	1.71	2.00	2.40	2.21
S. Em. ±	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.82	0.87	0.93	0.66	0.44	0.43	0.56	0.66	0.82	0.73

T1- Seed treatment of *Streptomycesalbofaciens* @ 10 g/kg of seed + Soil application of *Streptomycesalbofaciens* @ 50g/ pot, T2- Seed treatment with *B.japonicum* at @ 10 g/ kg of seed + Soil application of *B.japonicum* @ 50 g /pot on TOS, T3- Seed treatment of *Bacillus subtilis* @ 10g/kg of seeds + Soil application of *Bacillus subtilis* @ 50g/ pot on TOS, T4 - T1+ T2, T5 - T3 + T4, T6 - T5 + Fortification with humic acid @ 100g/ kg of bioinoculants as soil application @ 100g/pot on TOS, T7 - Seed treatment with Nativo 75 WP @ 1g/Kg of seeds, T8-Inoculated control, T9-Healthy control





Effect of *Holostemma Annulare* on Carbohydrate Metabolism in Streptozotocin–Nicotinamide- Induced Diabetic Rats by Modulating Key Enzymes

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ABSTRACT

Diabetes mellitus is a disease due to abnormality of carbohydrate metabolism and it is mainly linked with low blood insulin level or insensitivity of target organs to insulin. This is characterized by hyperglycemia and long term complications affecting the eyes, kidneys, nerves and blood vessels and is the most common endocrine disorder. Although the underlying mechanism of diabetic complications remains unclear, much attention has been focused on the role of oxidative stress. It has been suggested that oxidative stress may contribute to the pathogenesis of different diabetic complications. Diabetic experimental animal models have shown that oxidative stress causes persistent and chronic hyperglycemia, thereby depleting the activities of the antioxidant defense system and otherwise promoting free radicals generation. *Holostemma annulare* is a well-known medicinal plant, which is an important constituent in more than 34 ayurvedic preparations. The roots are reported to possess cooling, alterative, tonic and lactative properties. They are also used in diabetes, gonorrhoea, coughs, stomach-ache, consumption, fever. The ethanolic extract of *Holostemma annulare* roots has been reported to contain six amino acids, viz; alanine, aspartic acid, glucine, serine, threonine and valine. The benzene extract contains α -amyrin, lupeol and β -sitosterol.

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In the present investigation, we attempted further to investigate the alcoholic root extract of *Holostemma annulare* was studied for its antioxidant status and its effects on key enzymes of carbohydrate metabolism in streptozotocin and nicotinamide induced type 2 diabetic rats.

Keywords: *Holostemma annulare*, enzymes, carbohydrate metabolism etc.

INTRODUCTION

Diabetes mellitus is a condition caused by abnormalities in the metabolism of carbohydrates. It is primarily associated with low blood insulin levels or insulin-insensitive target organs. This is the most prevalent endocrine condition and is characterized by hyperglycemia and long-term problems affecting the kidneys, blood vessels, nerves, and eyes. Sexual disorders, ocular problems, neurological, nephrological, and dermatological complications are all possible outcomes of diabetes¹. In real terms, these side effects usually account for the majority of disease related societal healthcare expenses. Oxidative stress has drawn significant interest, despite the fact that the precise mechanism behind diabetes problems remains unclear. Oxidative stress has been proposed as a potential factor in the pathophysiology of several diabetes problems. Experimental animal models of diabetes mellitus have demonstrated that oxidative stress results in chronic and persistent hyperglycemia, which in turn reduces the antioxidant defense system's activity and promotes the production of free radicals. A huge perennial plant with a somewhat reddish stem that climbs and is laticiferous, is a member of the Asclepiadaceae family². The longest roots reach up to 1 m in length, are twisted, cylindrical in shape, tapering towards the tip, brown-yellow in color. The thickness of the roots depends on their age and the amount of starch present. The surface texture is relatively smooth except for some fine root marks³. *Nighantusamgaram* has six species of *Holostemma annulare* grass. The plant is found in tropical Himalaya, Dehradun, Konkan, Bombay, Deccan, Canara, Karnataka, Kerala and Kanyakumari. It grows in hedgerow and open woodland, especially on the lower slopes of hills⁴. *Holostemma annulare* is a popular medicinal plant and an important part of more than 34 Ayurvedic preparations. The roots are said to be refreshing, expectorant, tonic and expectorant. It is made into a paste and applied for ophthalmia and orchitis. It is also used for diabetes, gonorrhoea, cough, stomachache, consumption, fever and tridosha. The ethanol extract from the roots of *Holostemma annulare* contains six amino acids. Alanine, aspartic acid, glucine, serine, threonine, and valine. Benzene extract contains α -amyrin, lupeol, and β -sitosterol. In the present investigation, we attempt to re-examine the antioxidant power of the alcoholic root extract of *Holostemma annulare* and its effects on the main levels of carbohydrate metabolism in streptozotocin and nicotinamide type 2 diabetic rats⁵.

METHODS AND MATERIALS

Compound microscope, stage micrometer, camera lucida, drawing sheet(black), glass slide, Leica DMLS microscope attached with Leitz MPS 32 camera, silica crucible, ashless filter paper(Whatmann no.44), Petri dish, UV apparatus, stoppered conical flask, magnetic stirrer, alcohol(95%), chloroform, water, chloral hydrate solution, phloroglucinol, hydrochloric acid, glycerin, sodium hydroxide, petroleum ether, acetone, benzene and chloroform.

Chemicals and Instruments

The following chemicals were used for the study: Glucose-6-phosphate dehydrogenase, glucose-6-phosphate, lactate dehydrogenase, streptozotocin, ascorbic acid, metaphosphoric acid, O-phosphoric acid, magnesium chloride, EDTA, sodium citrate, phenazine methosulfate, nitro blue tetrazolium chloride, NADH, NADPH, ATP, glutathione, 5, 5 dithio nitro bis benzoic acid, tocopherol, disodium hydrogen phosphate, potassium hydrogen phosphate, 2,4 dinitro phenyl hydrazine, sodium pyruvate, Tris buffer sodium pyrophosphate, nicotinamide. A UV spectrophotometer, homogenizer, centrifuge and pH meter were the instruments used for the study.



**Mohini Upadhye et al.,****Part used: Roots****Medicinal properties and uses**

The roots are reported to be refreshing, tonic, and expectorant. It is made into a paste and used for ophthalmitis and orchitis. It is also used for diabetes, gonorrhoea, cough, stomachache, fever and tridosha⁵.

Constituents

The ethanolic extract of *H.annulareroots* contain six amino acids, viz., alanine, aspartic acid, glycine, serine, threonine and valine and the benzene extract contains alpha amyryin, lupeol and beta- sitosterol⁶.

Method for anatomical study

To get rid of the coloring material, free-hand pieces of the stems that had been soaked for the entire night were cooked in choral hydrate. After choosing the clear parts, they were mounted with glycerin on a spotless glass slide and covered with a cover slip. After that, the portion was seen at low power (10 X and 40 X)^{2,3}.

Photomicrography

The photomicrography of the sections at different magnifications as demanded by the anatomical details was taken with the help of the audiovisual unit. The microphotographs were taken using Leica DMLAS microscope, attached with Leitz MPS 32 camera.

Powder Analysis

The dried roots of *Holostemma annulare* were examined for its macroscopic character. The powder of the stems were passed through sieve no.60 and observed under microscope for the microscopical character. The powder was boiled with chloral hydrate to remove colouring matters and viewed under microscope after mounting it on a glass slide using glycerin covering with a cover slip. Then the powder was stained with phloroglucinol in the presence of hydrochloric acid for the lignified structures and again it was viewed under microscope as described earlier. Further iodine water was used to locate the starch⁵.

Preparation of Extract**Ethanol extract**

H. annulare roots (160 g) that had been shade-dried and coarsely powdered were extracted with ethanol in a Soxhlet extractor for 72 hours. After cooling and filtering the resulting dark-brown extract, the solvent was extracted in a vacuum and recovered. For further tests, the drug residue kept in a desiccators was utilized. In terms of dry material, the w/w yield was 20%. The dehydrated extract was suspended in 2% gum acacia solution for animal research.

Aqueous extract

The marc obtained after ethanolic extraction was dried and extracted with chloroform water by simple maceration technique. After the extraction, solvent was removed by distillation and concentrated in a suitable lyophilizer.

Animals

Healthy adult male Wistar albino rats weighing 250–300 g were used for the study. The animals were housed in polypropylenecages, maintained under standard conditions (12 h light/12 h dark cycle; temperature 25 ± 30°C; 35–60% humidity), and the rats were fed with a standard rat pellet diet and water ad libitum.

Experiment protocol

Induction of type 2 diabetes

Preparation of Nicotinamide solution:

The required amount of Nicotinamide was accurately weighed and then dissolved in required quantity of normal saline.





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Preparation of Streptozotocin solution:

Preparation of 0.1M citrate buffer solution pH4.5-

1. Accurately weighed quantity of trisodium citrate (14.9 g) was dissolved in sufficient distilled water to produce 1000 ml and the pH(4.5) was adjusted using conc. HCl.
2. A solution of STZ was prepared by dissolving the weighed quantity of streptozotocin in 0.1M freshly prepared ice-cold citrate buffer (pH4.5) solution. The solution of STZ so prepared was administered in the volume of 0.5-1ml.
3. Selected male animals of 90 days old, weighing between 250-300g, fasted overnight were administered with Nicotinamide 120 mg/kg i.p. route and after 15 min Streptozotocin 60mg/kg IP. Fasting blood sugar levels were determined on 12th day to confirm stable hyperglycemia.
4. After confirmation of stable hyperglycemia, the diabetic rats were divided into different groups of 6 rats each. That day was considered as day zero⁷.

Experimental Design

The animals were divided into four groups (n = 6); normal rats administered with 2% gum acacia solution, diabetic rats administered with 2% gum acacia solution, diabetic rats administered with H. annulare extract 250 mg/ kg and diabetic rats administered with H. annulare alcoholic extract 500 mg /kg for 15 days orally.

Blood Sample

At the end of day 12, the blood samples were collected under light ether anesthesia retro-orbitally from the inner canthus of the eye using capillary tubes (Micro Hemocrit Capillaries, Mucaps). Blood was collected in fresh vials containing anticoagulant, and serum was separated in a centrifuge at 2000 r.p.m. for 2 min.

Collection of Organs

The animals were euthanized using an overdose of intraperitoneal anesthesia, and tissue samples were collected for the assessment of the following parameters. Estimation of Enzymes in Carbohydrate Metabolism The following parameters were evaluated.

Hexokinase

The hexokinase assay is based on the reduction of NAD through a coupled reaction with glucose-6-phosphate dehydrogenase and is determined spectrophotometrically by measuring the absorbance at 340 nm⁸.

Specimen

The excised liver tissue homogenate was prepared in saline.

Reagents

To 0.1 ml of homogenate was added 2.28 ml of

1. Tris(200 mmol l/1), MgCl₂ buffer (20 mol l/1) pH 8,
2. 0.5 ml of 0.67 M glucose.
3. ml of 16 mM ATP.
4. ml of 6.8 mM NAD.
5. ml of 300 U ml of 1 glucose-6-phosphate dehydrogenase.
6. The solution was mixed thoroughly, and the absorbance was measured at 340 nm^{9,10}. Mixed thoroughly and the absorbance was measured at 340 nm.

Reagent	Blank	Sample (ml)
Tris- MgCl ₂ buffer	2.28	2.28
Glucose	0.5	0.50
ATP	0.1	0.1





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NAD	0.1	0.1
G6PDH	0.01	0.01
Homogenate	-	0.1

Mixed thoroughly and the absorbance was measured at 340 nm.

Calculation

The hexokinase activity in the tissue was estimated and the results were expressed in U/gm.

Glucose-6-Phosphate Dehydrogenase

The rate of increase in absorbance is the measure of glucose-6-phosphate dehydrogenase activity. The addition of maleimide inhibits the oxidation of reaction products by 6-phospho gluconolactone.

Specimen The liver tissue was excised and rinsed with saline solution and the homogenate was prepared in saline solution¹⁰.

Reagents

To 0.02 ml of homogenate were added 0.6 ml of distilled water.

- 0.1ml of 3.8 mmol/l of NADP.
- Tris buffer, 0.5 mol/l
- 6.05g of Tris base dissolved in 70-80 ml water. The pH was adjusted to 7.5 with HCl and the volume made upto 100ml.
- MgCl₂, 0.63 mol/l
- 1.28g in 100ml water.
- Glucose 6 phosphate, 33mol/l
- 531 in 100 ml water¹¹.

Reagents	Sample	Blank
Distilled water	0.6	0.6
NADP	0.1	0.1
Tris buffer	0.1	0.1
MgCl ₂	0.1	0.1
Glucose 6-phosphate	0.1	0.1

Lactate Dehydrogenase

Lactate dehydrogenase catalyzes the conversion of L-lactate to pyruvate with simultaneous reduction and oxidation of NAD to NADH. The change in absorbance with time as a result of the conversion of NAD to NADH is directly proportional to LDH activity.

Specimen

The liver and kidney homogenate was prepared in saline. The supernatant was obtained by centrifugation of the homogenate.

Reagents

- Tris/ NaCl Solution (Tris 81.3mmol, NaCl:0.3mmol, pH 7.2). 0.98 g of Tris and 1.19g of NaCl in 50 ml of the water and the pH is adjusted to 7.2 at 30° C and made upto the volume 100ml . This solution is stored at -0.4° C.
- Tris/ NaCl/ NADH solution (Tris 81.3 mmol/l, NaCl 203.2 mmol/l, NADH 0.244 mmol/l, pH 7.2) 0.009g of NADH, disodium salt was dissolved in 50 ml of the solution A. This solution can be frozen.
- Tris/NaCl/ pyruvate solution(Tris 81.3 mmol/l, NaCl 203.2 mmol/l, pyruvate 9.76 mmol/l, pH 7.2) 0.009g of pyruvate, crystallized monosodium salt in 50ml of the solution A. This solution is stored at 4° C or -20° C.



**Mohini Upadhye et al.,****Procedure**

Tris/ NaCl/ NADH.....2.5 ml

Sample.....0.05 ml

Mixed thoroughly and the solution brought at 30°C.

Tris/NaCl/ pyruvate.....0.5 ml

Mixed and the absorbance measured at 339 nm after exactly at 1 min, 2 min, upto 4 min¹⁰.

Calculation

The LDH activity was calculated and expressed in U/gm.

Glucose-6-Phosphatase

Glucose-6-phosphatase catalyzes the conversion of glucose-6-phosphate to glucose. The rate of increase in absorbance at 700 nm is a measure of glucose 6 phosphatase activity. The activity is terminated by the addition of TCA/Ascorbate.

Specimen

The liver was homogenized in ice-cold sucrose (250 mM) solution. The homogenate was centrifuged for 30 min at 9000rpm at 2°C¹².

Reagents

1. Sucrose/EDTA buffer
2. Imidazole buffer (100 mM, pH 6.5).
3. Na₂HPO₄(1.5 Mm)
4. TCA/Ascorbate.
5. Ammonium molybdate (1% w/v).
6. Sodium citrate (2% w/v)¹³.

Procedure

To 0.1 ml of sucrose/EDTA buffer were added. 0.1 ml of glucose-6-phosphate (100 mM), 0.1 ml of imidazole buffer (100 mM, pH 6.5) and 0.1 ml of homogenate, with thorough mixing. The tubes were incubated at 37° C for 15 min. The enzymatic activity was terminated by the addition of 2 ml of TCA/ Ascorbate (10%/2% w/v), and the solution was centrifuged at 3000 r.p.m. for 10 min. To 1 ml of clear supernatant were added 0.5 ml of ammonium molybdate (1% w/v) and 1 ml of sodium citrate (2%, w/v). The absorbance was measured at 700 nm. The enzyme activity was expressed as unit per gram per minute in tissue¹⁴.

Calculation

The Glucose 6- phosphatase activity in the tissue was calculated and the results were expressed in U/gm in tissue.

Estimation of Antioxidant Parameters

Enzymatic antioxidants glutathione synthetase and glutathione peroxidase, catalase, peroxidase, superoxide dismutase and nonenzymatic antioxidants were determined.

Glutathione Synthetase

Virtually all of the non protein sulfhydryl groups of RBCs are in the form of reduced GSH. 5,5- di thiobis (2- nitro Benzoic acid) is a disulfide chromogen that is readily reduced by sulfhydryl compounds to an intensely yellow compound. The absorbance of the reduced chromogen is measured at 412 nm and is directly proportional to the GSH concentration^{14,15}.

Specimen

Assay was conducted in liver and kidney. The excised organs were rinsed with ice cold saline and blotted dry. It was homogenized in 5 volumes of 1% w/v picric acid. The homogenate was centrifuged. The supernatant was used for the assay^{16,17}.





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Reagents

1. Precipitation solution
Dissolved 1.67g of glacial meta phosphoric acid, 0.20g disodium EDTA and 30g of NaCl in distilled water and made upto the volume 100 ml. A fine precipitate may form owing to EDTA, but this does not interfere with the test.
2. Disodium phosphate solution, 0.3 mol/l
4.26g of disodium hydrogen phosphate was dissolved in distilled water and made upto the volume 100 ml.
3. DTNB reagent
40 mg of DTNB was dissolved in sodium citrate (1g/dl) and made upto 100 ml¹⁸

Reagent (ml)	Blank (ml)	Sample (ml)
Filtrate	-	2
Precipitating solution	1.2	-
Water	0.8	-
Na ₂ HPO ₄ solution	8	8
DTNB solution	1	1

Procedure

1. 0.2 ml of homogenate was added to the test tube and dissolved in 1.8 ml water. The solution was mixed thoroughly.
2. 3 ml of precipitation solution was added and mixed.
3. Allowed to stand for 5 min at room temperature and filtered through coarse filter paper.
4. Then, the absorbance was measured at 412 nm^{19,10}

Calculation

The GSH concentration in the tissues was calculated and the results were expressed in U/g/min.

Peroxidase

A resonance stabilized radical cation (ABTS⁺) is formed if an excess of substance is used. The amount of ABTS⁺ is proportional to the loss of H₂O₂. Thus with excess POD, the reaction may be used in H₂O₂ determination. Within a certain range, the amount of degraded H₂O₂ is proportional to the POD added.

Specimen

The liver and kidney tissue homogenized in phosphate buffer pH 6. The homogenate was used for the assay.¹⁰

Reagents

1. ABTS solution (2×10 mol/l)
1.1g of ABTS (diammonium salt) dissolved in 100 ml of aqueous phosphate buffer, 0.067 mol/l, pH 6 (0.144g sodium dihydrogen phosphate and 0.798g potassium dihydrogen phosphate in 100 ml water).
2. H₂O₂ (10 mol/l)
The commercial solution of 10 mol/l is diluted to 0.1 mol/l
3. POD (for calibration purpose)
Lyophilized horse radish POD of the highest available purity (250U/mg) dissolved in various concentrations in phosphate buffer. POD solution should be kept at 0-4 °C²⁰.

Reagents	Blank	Sample
ABTS solution	0.2 ml	0.2 ml
H ₂ O ₂ solution	0.2 ml	0.2 ml
Homogenate	-	2 ml
P3whosphate buffer	2 ml	-



**Procedure**

The absorbance was measured at 405 nm.

Calculation

The peroxidase activity was calculated and expressed in U/gm.

Catalase

In the UV range H₂O₂ shows a continual increase in absorption with decreasing wavelength. The decomposition of H₂O₂ can be followed directly by a decrease in absorbance at 240 nm. The difference in absorbance per unit time is a measure of catalytic activity.¹⁶

Specimen

The liver and kidney were excised and homogenized with 1% Triton X-100. Further dilution can be made with phosphate buffer pH 7(1:100)^{21,22}

Reagents

1. Phosphate buffer (50 mmol/l, pH 7)
0.68g of potassium dihydrogen phosphate and 0.89g of disodium hydrogen phosphate were dissolved in water. The pH is adjusted to 7 and the volume made upto 100 ml.
2. Hydrogen Peroxide (30 mmol/l)
0.34 ml of 30% hydrogen peroxide was dissolved in phosphate buffer and made up to a volume 100 ml. This should be prepared freshly.^{23,24}

Reagent	Blank	Sample
Phosphate buffer	1 ml	-
Homogenate	2 ml	2 ml
H ₂ O ₂	-	1 ml

Procedure

Mixed well and the absorbance measured at 240 nm . The reading were taken at different time interval (5 or 10 sec)¹⁰

Calculation

The catalase activity was calculated and the results were expressed in U/g/min × 10³.

Superoxide dismutase

This method is based on the inhibition of NADH-dependent nitro blue tetrazolium reduction by dismutase. Inhibition of 5th chromogen formation by superoxide dismutase was linear with increase in enzyme concentration.¹⁶

Specimen

The liver and kidney were homogenized in sodium pyrophosphate buffer pH 8.3 and the homogenate used for the assay.²⁵

Reagents

1. Sodium pyrophosphate buffer 0.052 M pH 8.3.
2. Phenazine methosulfate (186 μM)
3. NBT (300μM)
2.6034g in 10 ml water.
4. NADH (780 μM)
9 mg in 10 ml water^{26,27}



**Mohini Upadhye et al.,****Procedure**

1. 1.2 ml sodium pyrophosphate buffer, 0.1 ml of phenazine metho sulfate, 0.3 ml of NBT were added in the test tube.
2. 1.2 ml homogenate was added to the test tube. The reaction was started by the addition of 0.2 ml of NADH.
3. After incubation at 30° C for 90 sec, the reaction was stopped by the addition of 1 ml of glacial acetic acid.
4. The reaction mixture was stirred vigorously and shaken with 4 ml butanol.
5. The mixture was allowed to stand for 10 min, centrifuged and the butanol layer was taken out.
6. Colour intensity of the chromogen in the butanol was measured at 560 nm¹⁰.
Calculation The superoxide dismutase activity was determined in the tissue and the results were expressed in U/gm.

RESULTS AND DISCUSSION

The plant *Holostemma annulare* Rosh, Asclepiadaceae was studied for its Pharmacognóstical, phytochemical and antidiabetic activity. Pharmacognóstical studies on the plant which is macroscopy, microscopy, powder analysis are a valuable source of information and provide suitable standards for the identification of this plant material for future investigation. Preliminary phytochemical studies on the plant revealed the presence of mucilage, flavonoids, glycosides, steroids and carbohydrates. Further fractionation of the ethanolic extract led to the isolation of uncharacterized steroidal compounds. The roots of *Holostemma annulare* are long, slightly cylindrical, unevenly twisted, and taper gradually towards the tip. Only a few scars of rootlets break the very smooth surface of the roots. Upon closer examination, the organoleptic features exhibit a color that varies from yellow-brown to brownish-black, a sweet taste, and a faintly sweet odor. Under a microscope, the transverse slice of the root exhibits a cork layer comprising four to five layers of tangentially elongated cells. The cells in the outermost row are light brown in color, and a distinct cork or cambium is seen. The 4-5 layers of tangentially elongated cells that make up the phelloderm are mostly composed of starch grains, and some of these cells also exhibit prominent calcium oxalate crystals. Large in size, with strong walls and many pits or pith chambers, Sclereids are found in the deepest levels of the phelloderm. Five to six layers of cortical cells rich in starch granules are seen as one moves farther within. Radially extended uniseriate rays identify the phloem, whereas the xylem makes up around two-thirds of the radius and is composed of lignified parenchyma with thick walls. In addition, there are prominent uniseriate medullary rays on the primary xylem (figure 1). The properties of root cork powder show that it is composed of four to five layers of empty, thin-walled, tangentially elongated cells. These outermost layer of cell has a light brown tint to it. There are also clearly visible sclereids, or stone cells, which have an isodiametric form.

These stone cells have thick, lignified walls that are filled with many pits or pit cavities. Cluster crystals of calcium oxalate are also seen in the sample. In addition, pieces of spiral, annual, and reticulate vessels can be found in the powder. In the end, the sample exhibits fibers that are both lignified and non-lignified (As per figure). The roots of the plant *Holostemma annulare* have been documented for its use in diabetes mellitus¹. As the activity has not been documented, the present study was undertaken to evaluate the antidiabetic effect of the alcoholic and aqueous extracts in streptozotocin and nicotinamide induced NIDDM rats. The acute toxicity studies revealed the non-toxic nature of the aqueous and alcoholic extracts of *Holostemma annulare*. The extracts were safe up to 3000mg/kg. No lethality or any toxic reactions were found up to the end of the experimental period. The fundamental mechanism underlying hyperglycemia in diabetes mellitus involves the over production (excessive hepatic glycogenolysis and gluconeogenesis) and decreased utilization of glucose by the tissues²⁸. Persistent hyperglycemia, the common characteristic of diabetes, can cause most diabetic complications. In all patients, treatment should aim to lower blood glucose to or near normal levels²⁹. In our investigations, oral glucose tolerance tests revealed the antidiabetic activity exerted by the aqueous and alcoholic extract of *Holostemma annulare*. The alcoholic extract in the dose of 500mg/kg showed a significant reduction on blood glucose level within 2 hr. It is well documented that STZ destroys the beta cells of the pancreas and causes hyperglycemia in rats. Studies on STZ induced diabetic animals treated with test extracts revealed significant reduction in the blood sugar level when compared with diabetic control groups at the



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end of a 15-day experimental period. The significant decrease in the levels of diabetic rats treated with the extracts may be by stimulation of residual pancreatic mechanism or by probably increasing peripheral utilization of glucose³⁰. Significant reduction in urine volume, water intake and increase in food intake was observed at the end of the experimental period. These parameters support the potential antidiabetic activity exerted by the test extracts. The present study showed a marked increase in the serum triglycerides and cholesterol levels in control diabetic rats, which are in agreement with the findings of Nikkila and Kekki, 1973, and Chase and Glasgow, 1976 it is well known that under normal circumstances insulin activates the enzyme lipoprotein lipase which hydrolyzes the triglycerides. Insulin deficiency results in the failure to activate the enzymes thereby resulting in hypertriglyceridemia^{31, 32}. The significant control of the levels of serum lipids in the extract treated diabetic rats may therefore be because of improvements in the insulin level. Significant lowering of total cholesterol and raise in HDL cholesterol is a very desirable biochemical state for prevention of atherosclerosis and ischaemic conditions³³. Impairment of glycogen synthesis in diabetic rats has been reported by Whitton and Hems, 1975. The untreated control group animals in our investigation gave inferences in compliance with the above findings. The significant increase in the liver glycogen levels in extract treated animals may be due to the reactivation of glycogen synthase systems. The activities of different key enzymes viz, Hexokinase, Glucose-6-phosphate dehydrogenase and lactate dehydrogenase levels in diabetic animals treated with 500 mg/kg of the alcoholic extract of *H. annulare* showed better enzyme activity than those treated with the lower (250 mg/kg) dose of the alcoholic extract.

The activity was more in alcoholic extract than aqueous extract. The significant increase in the levels of Hexokinase, a key glycolytic enzyme known to decrease in the diabetic state³⁴, may be due to the direct stimulation of glycolysis in tissues with increased glucose removal from the blood. The significant reversal of diabetes induced decreased levels of Glucose-6-phosphate dehydrogenase and lactate dehydrogenase may be attributed to an increase in Glucose utilization through the pentose phosphate pathway³⁵, interfering with the mitochondrial respiratory chain and promoting the peripheral glucose utilization by enhancing anaerobic glycolysis³⁶. Treated groups exhibited a significant decrease in the levels of Glucose-6-phosphatase, a key enzyme in gluconeogenesis, plays an important role in glucose homeostasis in the liver and kidney³⁷. The decreased levels observed in treated diabetic animals may be because of the suppression of hepatic gluconeogenesis and glucose output from liver. Serum urea and creatinine levels were also decreased significantly compared with the diabetic control. Total Protein levels were also increased in the extract treated diabetic animals compared to the diabetic animals. Antioxidants are of two types: enzymatic and nonenzymatic antioxidants. Catalase, Superoxide Dismutase, Peroxidase and Glutathione synthetase are examples of enzymatic antioxidants. Superoxide dismutase and Catalase are considered primary enzymes since they are involved in the direct elimination of reactive oxygen species³⁸. Superoxide dismutase is an important defense enzyme, which catalyzes the dismutation of superoxide radicals, and Catalase is a hemoprotein, which catalyzes the reduction of Hydrogen peroxides and protects tissues from highly reactive hydroxyl radicals³⁹. The reduced activity of Superoxide dismutase and Catalase in the liver and kidney observed during diabetes may result in deleterious effects as a result of the accumulation of superoxide anion radicals and Hydrogen peroxide⁴⁰.

Glutathione synthetase, the most important biomolecule protecting against chemical induced toxicity, participates in the elimination of reactive intermediates by reduction of hydroperoxide in the presence of Glutathione peroxidase⁴¹. The decreased level of glutathione synthetase observed in the diabetic animals represents increased utilization resulting from oxidative stress⁴². In our study the activity of enzymatic antioxidants (catalase, glutathione synthetase, peroxidase and superoxide dismutase) increased significantly in extract-treated diabetic animals. Tocopherol is a nonenzymatic antioxidant, which reduces lipid hydroperoxides, generated during the process of peroxidation and protects cell structures against damage⁴³. In our investigations, the levels of both enzymatic and nonenzymatic antioxidants, which declined in the diabetic animals, were significantly restored on treatment with the alcoholic extract. The overexpression of these antioxidant parameters in diabetic rats treated with *Holostemma annulare* implies that this potential oxidant defense is reactivated by the active principles of *Holostemma annulare*, with an increase in the capacity for detoxification through enhanced scavenging of oxy radicals. The significant inhibitory activity in in vitro antioxidant studies of the test extracts with DPPH, ABTS & reduction of ferric ions, indicate the free radical scavenging activity of these extracts. Our studies have shown that the plant *Holostemma*



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annulareis endowed with marked antidiabetic activity with minimal toxicity. Its potent antidiabetic activity may be attributed to its principal constituents such as flavonoids. However, longer duration studies of *Holostemma annulare* are and its isolated compounds on chronic models are necessary to develop a potent antidiabetic drug.

CONCLUSION

In streptozocin-induced diabetic rats, these results indicate that *Holostemma annulare* aqueous extract has anti-diabetic properties due to its hypolipidemic, antioxidant, and protective effects on pancreatic β -cells, which help to increase glucose metabolism. Its potent antidiabetic activity may be attributed to the steroids and flavonoids present therein. Plant sterols inhibit the absorption of dietary cholesterol and flavonoids are reported to be useful in the treatment of diabetes mellitus.

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Table.1 Effect of aqueous and alcoholic root extracts of *Holostemma annulare* on glycolytic enzyme- Hexokinase level in NIDDM rats.

Group	Treated (n=6)	Dose	Hexokinase
			Liver(U/g)
1	Normal control	-	9.6 ± 0.2
2	Diabetic control	-	2.3 ± 0.1
3	Aq. Ext. A	250 mg/kg	4.0±0.2
4	Aq. Ext. B	500 mg/kg	4.28±0.8 ^b
5	EtOH Ext. A	250 mg/kg	5.2 ± 0.1 ^{a,b}
6	EtOH Ext. B	500 mg/kg	8.4 ± 0.6 ^{a,b}
7	Metformin	75 mg/kg	8.9±0.9

Table . 2 Effect of aqueous and alcoholic root extracts of *Holostemma annulare* on glycolytic enzyme- glucose 6 PDH level in NIDDM rats.

Group	Treated (n=6)	Dose	Glucose 6 PDH
			Liver(U/g)
1	Normal control	-	17.1 ± 1.3
2	Diabetic control	-	12.3 ± 1.6
3	Aq. Ext. A	250 mg/kg	12.7 ± 4.8
4	Aq. Ext. B	500 mg/kg	13.1 ± 3.3 ^b
5	EtOH Ext. A	250 mg/kg	12.9 ± 1.5 ^{a,b}
6	EtOH Ext. B	500 mg/kg	13.9 ± 1.5 ^{a,b}
7	Metformin	75 mg/kg	18.5 ± 1.2

Table.3 Effect of aqueous and alcoholic root extracts of *Holostemma annulare* on glycolytic enzyme- Lactate Dehydrogenase level in NIDDM rats

1	Normal	-	0.74 ± 0.02	1.4 ± 0.3
2	Control	-	0.23 ± 0.1	0.6 ± 0.2
3	Aq. Ext. A	250 mg/kg	0.35±0.05 ^b	0.9 ± 0.4 ^b
4	Aq. Ext. B	500 mg/kg	0.37±0.07 ^b	0.9 ± 0.6 ^{b 1}
5	EtOH Ext. A	250 mg/kg	0.42 ± 0.06 ^b	0.9 ± 0.7 ^b
6	EtOH Ext. B	500 mg/kg	0.68± 0.03 ^{a,b}	1.1 ± 0.7 ^{a,b}
7	Metformin	75 mg/kg	0.69 ± 0.87	12.1 ± 1.6

Table.4 Effect of aqueous and alcoholic root extracts of *Holostemma annulare* on glycolytic enzyme- Glucose 6 Phosphate level in NIDDM rats.

Group	Treated (n=6)	Dose	Glucose 6 Phosphatase	
			Liver (U/g/min)	Kidney (U/g/min)





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1	Normal control	-	10.5 ± 1.3	12.9 ± 2.1 ^a
2	Diabetic control	-	30.6 ± 1.4	18.2 ± 1.5
3	Aq. Ext. A	250 mg/kg	22.4 ± 1.9 ^b	17.9 ± 1.8
4	Aq. Ext. B	500 mg/kg	21.5 ± 1.2 ^b	17.2 ± 1.3 ^b
5	EtOH Ext. A	250 mg/kg	20.7 ± 1.4 ^{a,b}	16.3 ± 1.4 ^{a,b}
6	EtOH Ext. B	500 mg/kg	17.3 ± 1.5 ^{a,b,c}	15.5 ± 1.4 ^{a,b,c}
7	Metformin	75 mg/kg	12.6 ± 0.25	12.7 ± 1.2

Table .5 Effect of aqueous and alcoholic root extracts of *Holostemma annulare* on glycolytic enzyme- Glutathione Synthetase level in NIDDM rats.

Group	Treated (n=6)	Dose	Glutathione Synthetase	
			Liver (U/g/min)	Kidney (U/g/min)
1	Normal Control	-	5.5 ± 0.3 ^a	2.1 ± 0.4 ^a
2	Diabetic Control	-	2.2 ± 0.4	1.6 ± 0.3
3	Aq. Ext. A	250 mg/kg	2.6 ± 0.9	1.7 ± 0.3
4	Aq. Ext. B	500 mg/kg	2.8 ± 0.1 ^{a,b}	1.7 ± 0.4 ^b
5	EtOH Ext. A	250 mg/kg	2.8 ± 0.3 ^{a,b}	1.7 ± 0.1 ^b
6	EtOH Ext. B	500 mg/kg	3.4 ± 0.4 ^{a,b,c}	1.8 ± 0.5 ^{a,b,c}
7	Metformin	75 mg/kg	5.3 ± 0.2	2.0 ± 0.1

Table.6 Effect of aqueous and alcoholic root extracts of *Holostemma annulare* on glycolytic enzyme- Peroxidase level in NIDDM rats.

Treated (n=6)	Dose	Peroxidase	
		Liver (U/g/min)	Kidney (U/g/min)
Normal Control	-	2.1 ± 0.1	0.6 ± 0.03
Diabetic Control	-	1.1 ± 0.3	0.1 ± 0.02
Aq. Ext. A	250 mg/kg	1.3 ± 0.1 ^b	0.2 ± 0.05
Aq. Ext. B	500 mg/kg	1.4 ± 0.6 ^{a,b}	0.2 ± 0.05 ^b
EtOH Ext. A	250 mg/kg	1.4 ± 0.2 ^{a,b}	0.2 ± 0.03
EtOH Ext. B	500 mg/kg	1.6 ± 0.3 ^{a,b}	0.3 ± 0.06 ^{1a,b}
Metformin	75 mg/kg	2.2 ± 0.78	0.5 ± 0.9

Table.7 Effect of aqueous and alcoholic root extracts of *Holostemma annulare* on glycolytic enzyme- Catalase level in NIDDM rats.

Treated (n=6)	Dose	Catalase	
		Liver (U/g/minx10 ³)	Kidney (U/g/minx10 ³)
Normal Control	-	35.3 ± 1.3 ^a	12.8 ± 1.1





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Diabetic Control	-	15.9± 1.1	7.4 ± 0.4
Aq. Ext. A	250 mg/kg	22.1± 1.9	9.9 ±0.9 ^{a,b}
Aq. Ext. B	500 mg/kg	23.7±2.2 ^b	8.0 ±0.3 ^{a,b}
EtOH Ext. A	250 mg/kg	22.9 ± 1.4 ^b	7.9± 0.7 ^{a,b}
EtOH Ext. B	500 mg/kg	29.3 ± 1.7 ^{a,b}	9.3 ± 0.9 ^{a,b}
Metformin	75 mg/kg	32 ± 0.3	12.2 ± 0.8

Table.8 Effect of aqueous and alcoholic root extracts of *Holostemma annulare* on glycolytic enzyme- Superoxide Dismutase level in NIDDM rats.

Group	Treated (n=6)	Dose	Superoxide Dismutase	
			Liver (U/g)	Kidney (U/g)
1	Normal Control	-	219.2±18.4	136.1 ±14.6
2	Diabetic Control	-	86.6± 22.6	65.6 ± 14.8
3	Aq. Ext. A	250 mg/kg	112.4 ± 18.3	85.3 ± 16.3 ^b
4	Aq. Ext. B	500 mg/kg	123.5 ± 22.1 ^a	92.9 ± 23.5 ^b
5	EtOH Ext. A	250 mg/kg	148.7 ± 28.7 ^{a,b}	98.7± 13.5 ^b
6	EtOH Ext. B	500 mg/kg	162.4 ± 15.9 ^{a,b}	121.0 ± 17.5 ^{a,b}
7	Metformin	75 mg/kg	198 ± 0.6	129 ± 0.7

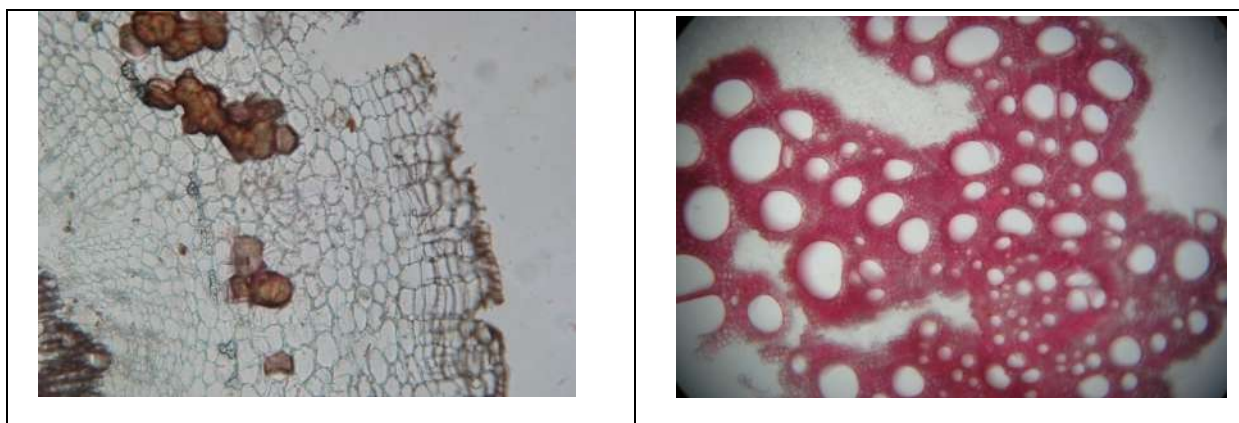
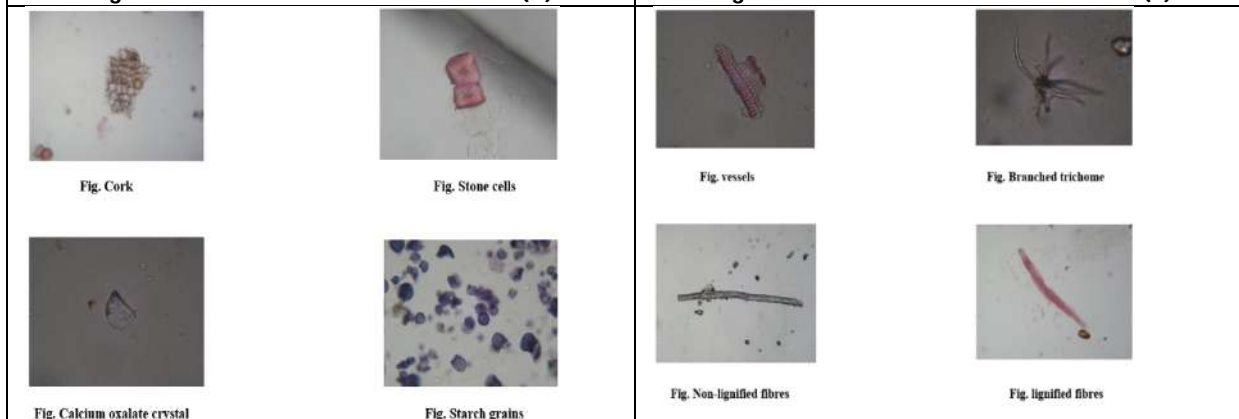


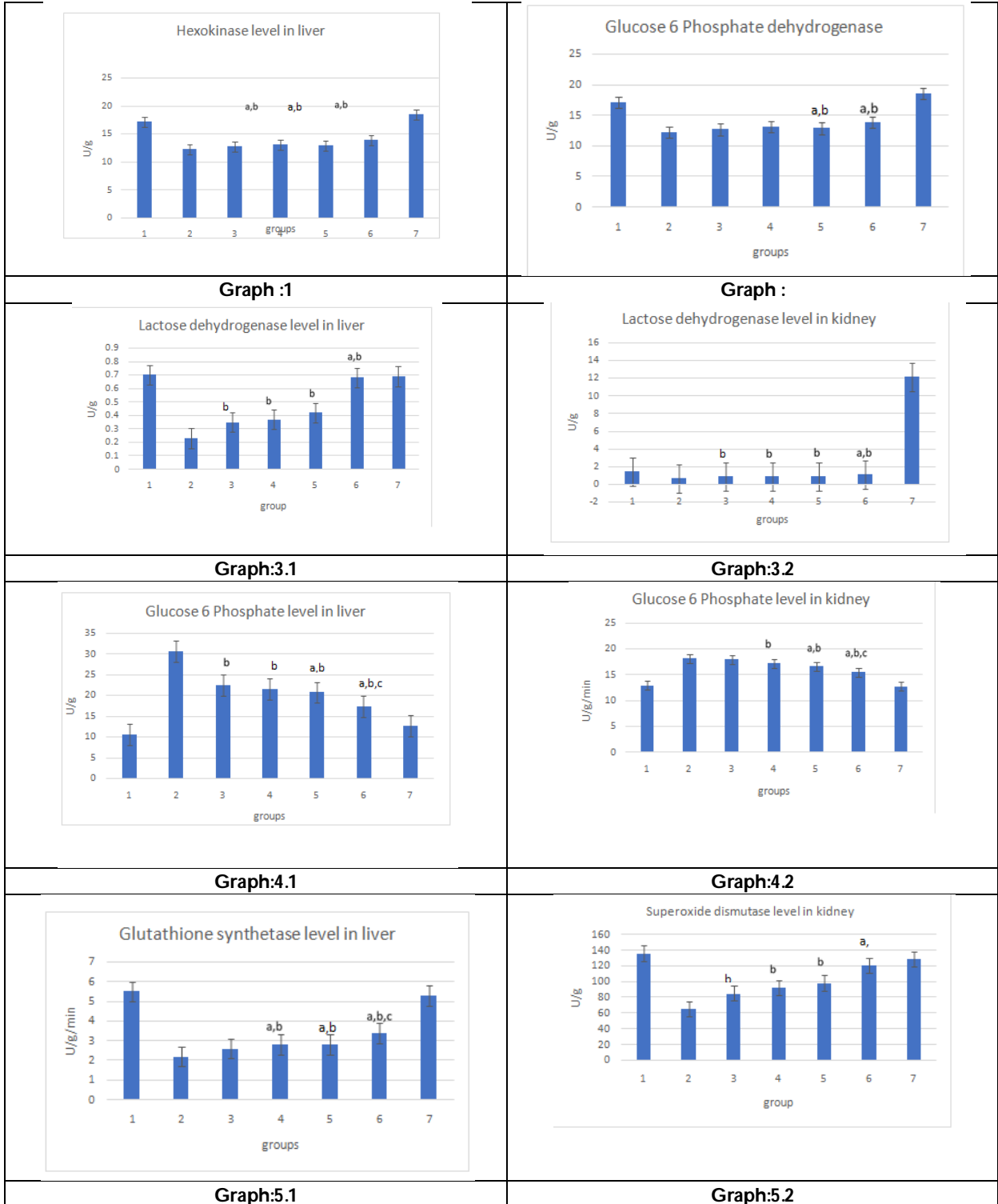
Fig.1 T.S of *Holostemma annulare* root (A)

Fig. 2. T.S of *Holostemma annulare* root (B)





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<p style="text-align: center;">Graph:6.1</p>	<p style="text-align: center;">Graph:6.2</p>
<p style="text-align: center;">Graph:7.1</p>	<p style="text-align: center;">Graph:7.2</p>
<p style="text-align: center;">Graph:8.1</p>	<p style="text-align: center;">Graph:8.2</p>





Assessment of Behavioural Changes and usage of Siddha Prophylactic Medicines during Covid-19 Pandemic in Children – A Cross Sectional Study

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ABSTRACT

The current outbreak of pneumonia, originating in Wuhan City, Hubei Province, China, since December 2019, is caused by a novel coronavirus referred to as '2019 novel coronavirus,' or 'COVID-19' by the World Health Organization (WHO). COVID-19, a pathogenic virus, has triggered a wide range of challenges during the pandemic, impacting mental health across all age groups, including children and adolescents. Feelings of grief, fear, and uncertainty, coupled with social isolation, increased screen time, and parental fatigue, have adversely affected the mental well-being of children. While friendships and family support typically serve as strong stabilizing forces for children, the COVID-19 pandemic has disrupted these important sources of support. In this study, the assessment of behavioural changes and evaluation of the usage of siddha prophylactic medicines, home remedies, yoga practices during the Covid-19 pandemic in children by using modified standard questionnaire. This study conducted in children attending Kuzhanthaimaruthuvam OPD, NIS by using direct interview method to the children and their informants, after obtaining proper consent from the informant of the children and assent from the children. There were significant behavioural changes like having trouble in concentrating on things, such as reading the newspaper or watching television; and problems paying attention in class or doing homework or reading a book or playing a game observed in these children. It is also observed that siddha prophylactic medicines were widely used among these children during the pandemic. Therefore, from this study it is observed that there is a need to develop healthy coping mechanisms during the current crisis.



**Subashini et al.,****Keywords:** COVID-19, Behavioural changes, Children, Siddha prophylactic medicines.

INTRODUCTION

A novel coronavirus (CoV) named '2019-nCoV' or '2019 novel coronavirus' or 'COVID19' by the World Health Organization (WHO) is in charge of the current outbreak of pneumonia that began at the early of December 2019 near in Wuhan City, Hubei Province, China. The COVID-19 pandemic emerged, presenting a complex array of challenges that impacted the mental health of individuals of all ages, including children and adolescents. Children have been particularly affected by feelings of grief, fear, uncertainty, social isolation, increased screen time, and parental fatigue, all of which have had a detrimental effect on their mental well-being. While friendships and family support typically serve as strong stabilizing forces for children, the COVID-19 pandemic has disrupted these essential sources of support.[2] There are more than 2.2 billion children in the world who constitute approximately 28% of the world's population. Since January 2020, various countries started implementing regional and national containment measures or lockdowns. In this backdrop one of the principal measures taken during lockdown has been closure of schools, educational institutes and activity areas. These inexorable circumstances which are beyond normal experience, lead to stress, anxiety and a feeling of helplessness in all [1]. Children have been at home for longer period of time than ever before. The closure of schools, absence of extracurricular and outdoor activities, changes in eating and sleeping routines, and limited peer interaction have contributed to feelings of monotony, distress, irritability, and various neuro-psychiatric symptoms. The negative impact of school closures and lockdown has been felt by children across diverse geographies, involving high and low-income settings. [2]

Despite the rapid implementation of remote learning, new health protocols, and reopening plans by national governments worldwide, the effectiveness and scope of these policies have significantly varied depending on the economic status of each country. Even short disruptions in children's schooling can have long-lasting negative impacts due to factors including the lack of structured programmes for catching up. In the siddha system, Epidemics /Pandemics are "UzhiNoi" or "Kothari Noi". In general, they are classified under "KollaiNoikal" (Communicable Diseases) which are most commonly occurred the time of "Ayana Santhi" months (Means end a month of UtharaAyanam&ThatchanaAyanam), fall on Aadi and Margazhi month in Tamil calendar. According to the Mukkutram Theory, it is believed that during those times, human immunity tends to be low.[4] In Guru Naadi, quoted, ThottruNoigal generally caused by Kirumi (pathogens). The symptoms are due to Noiyinvanmai (Immunity of individual), if it is good, he/she will not be affected.[4] The World Health Organization (WHO) promotes traditional medicines and developing new therapies in the search for potential treatments for COVID-19.[3] Marked as the initiator to combat with the existing COVID-19 pandemic, the Ministry of Ayush has published useful guidelines for the registered practitioners of Ayush Systems and also advices people to follow traditional medicines for the prevention of COVID-19. The Ministry of Ayush has introduced the "Ayush Sanjivani" mobile application, aimed at helping the public understand the measures taken to enhance immunity and maintain good health during the challenging COVID-19 situation. The Ministry launched a massive nationwide campaign to distribute its proven poly herbal Siddha formulation KabasuraKudineer for the benefit of the vast majority of peoples. And also, government has created awareness in using simple home remedies, yoga practices, pranayamam procedures and immune enhancing siddha formulations during the COVID-19 pandemic. In India, Children were advised to have herbal formulations to enhance the immunity and prevention of COVID-19. Children who are all visiting to our NIS-KM OPD also had siddha preventive measures for COVID-19. But there is no such data available about the children who consumed siddha medicines and also as prophylaxis during COVID-19. Therefore, it is essential to assess the impacts of COVID-19 lockdown on changes in behaviour and it is essential to know the new normalcy situation and how much children suffered due to pandemic effects. Also assess the usage of traditional medicines as protective factors such as siddha prophylactic medicines in children during the pandemic that could mitigate such impacts.



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MATERIALS AND METHODS

This hospital based observational cross sectional research was conducted in National Institute of Siddha, KuzhanthaiMaruthuvam OPD in 100 children. The Protocol was prepared and submitted to Screening committee followed by National Institute of Siddha's Institutional Ethical Committee (IEC) for ethical clearance on 25/11/2021(NIS/IEC/2021/MP-8). The study also registered in Clinical Trial Registry of India (CTRI) REF/2022/02/051359. Following the approval of IEC, the study commenced as a cross sectional observational study among the children attending the KuzhanthaiMaruthuvam OPD in NIS, Tambaram and their informants. After obtaining proper consent from the informant of the children, and assent from the children. Data were collected from the selected subjects using modified standard questionnaire. The questionnaire consists of two sections to assessing the behavioural changes in children and usage of siddha prophylactic medicines during COVID-19. The questionnaire was selected from the standard questionnaire called PHQ9 and article from American psychiatric association, siddha guidelines from government. The scoring includes not at all, several days, more than half the days, nearly every day, and also minimal, mild, moderate, severe. The children and informant were informed about the study before enrolment and their consent, assent forms and data were maintained confidentially. Then results were analysed in STATA software.

RESULTS AND DISCUSSION

This cross-sectional study was conducted among 100 children attending KM-OPD, NIS. The findings revealed the significant behavioural changes in children during pandemic and usage of siddha prophylactic medicines, home remedies, yoga practices in children during COVID-19 pandemic in children. As per the questionnaire, the results were obtained based on the children had behavioural changes more than half days in a month revealed that maximum number of about 29% children had problems in paying attention to their work. About 29% of children seemed angry or lost temper more than usual. About 27% of children having trouble in concentrating things such as reading newspaper. And 24% of children seemed more irritated/ annoyed than usual. Also 6% of children were felt nervous/anxious and were not been able to stop worrying, and minimum number of 7% children seemed sad or depressed for several hours. In this research, it was observed that siddha prophylactic medicines were widely used in children population for the prevention of COVID-19. The result based on the usage of siddha prophylactic medicines for more than half days in a month, maximum number of about 56% children were taken KabasuraKudineer as prophylactic medicine for prevention of COVID-19. it shows the increased level of awareness and usage of kabasurakudineer among children during pandemic period. And about 51% of children were taken immuno modulators such as Turmeric milk/pepper milk/ginger tea/athimathuram tea/amla/ neem leaves, also 52% of parents of these children were exposed and aware about these preparations like antiviral siddha herbs such as Thulasi kudineer/injisurasam/keezhanelli. The statistical findings revealed that, there were major significant behavioural changes in having trouble in concentrating on things, such as reading the newspaper or watching television. [significant value of 0.035], Problems in paying attention in class or doing homework or reading a book or playing a game [significant value of 0.002].

CONCLUSION

COVID-19 pandemic leads to a lot of undesirable effects in physical and mental health of children and their behaviours. During the pandemic most of the children's activities and behaviours have been affected due to closure of physical classes and introduction of virtual classes, lack of physical activity, aberrant dietary and sleeping habits. This study shows evidence on the impact of pandemic-related behavioural changes in children. The findings emphasize the importance for decision-makers to consider both the risks and benefits to children's health when implementing public health measures. It is advisable to parents and family members, included increasing communication with children to address their fears and concerns, playing collaborative games to alleviate loneliness,





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encouraging activities that promote physical activity, and using music therapy in the form of singing to reduce the worry, fear, and stress[6] This study revealed that the awareness about siddha prophylactic medicines, immuno modulator drugs are boomed among our population. Also, the usage of home remedies, yoga practices among the parents and the usage of siddha prophylactic medicines in children are extensively spread. Comparatively than normal times, the pandemic has brought more awareness and increased the usage of siddha medicines and home remedies, yoga practices. There is still the need for wide publicity to reach the root level of young minds of our country.

CONFLICT OF INTERESTS

The authors declare that there are no conflicts of interests.

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Table.1.

variable	Had problems paying attention when he/she was in class or doing his/her homework or reading a book or playing a game?
Not at all	44%
Several days	16%
More than half days	29%
Nearly everyday	11%

Table.2.

variable	Seemed angry or lost his/her temper?
Not at all	22%
Several days	17%
More than half days	29%
Nearly everyday	32%



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Table.3.

variable	Trouble concentrating on things, such as reading the newspaper or watching television?
Not at all	44 %
Several days	10%
More than half days	27%
Nearly everyday	19%

Table.4

variable	Seemed more irritated or easily annoyed than usual?
Not at all	29%
Several days	19%
More than half days	24%
Nearly everyday	28%

Table.5

variable	Did you used KabaSuraKudineer for immunity against COVID - 19?
Not at all	9%
Several days	32 %
More than half days	56%
Nearly everyday	3%

Table.6

variable	Whether you used any of this Immunomodulators like turmeric milk/pepper milk/inji tea/athimathuram tea?
Not at all	5%
Several days	24%
More than half days	51%
Nearly everyday	20 %





Synthesis of Sn and Ce based ZrO Nanocomposites and its Application in Photocatalytic Degradation of Methylene Blue Dye

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ABSTRACT

To synthesis Sn and Ce based ZrO nanocomposites via., hydrothermal method. The synthesized ZrO₂, Sn/ZrO₄ and Ce₂/Zr₂O₇ were characterized by various analytical techniques such as XRD, FT-IR, SEM, and UV-DRS. The crystalline sizes of the synthesized ZrO₂, Sn/ZrO₄ and Ce₂/Zr₂O₇ were 27.8, 37.6 and 43.2nm, respectively. The morphologies of the prepared materials were investigated using SEM, it was discovered that ZrO₂, Sn/ZrO₄ and Ce₂/Zr₂O₇ nanocomposite showed rod, irregular and spherical shapes. UV-DRS analysis was used to determine the bandgap of the synthesized Sn/ZrO₄ and Ce₂/Zr₂O₇ which was found to be 2.5 and 2.0 eV, respectively. The prepared materials were used as a catalyst for the photodegrading of methylene blue dye among which Ce₂/Zr₂O₇ material showed high degradation of the dye molecules up to 90%.

Keywords: The synthesized ZrO₂, Sn/ZrO₄ and Ce₂/Zr₂O₇ were characterized by various analytical techniques such as XRD, FT-IR, SEM, and UV-DRS.





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INTRODUCTION

In recent years, environmental contamination has grown to be a major problem. Pollution levels are rising daily, causing major and irreversible damage to the planet. It has been shown that the primary source of water contamination is industrial effluent. Photocatalytic degradation is a crucial stage in the treatment of wastewater that may get rid of hazardous heavy metal pollutants[1]. The drawbacks of conventional wastewater treatment applications include high separation costs and the secondary generation of pollutants related to adsorption, clotting, and membrane separation all of which have significant operational costs. When present, metal oxide nanocomposites promote photocatalytic degradation[2]. Sn/ZrO₄ and Ce₂/Zr₂O₇ nanostructures are of interest to researchers in a number of domains, including photocatalytic performance, gas sensors, glucose sensors, and solar cells. All things considered Ce₂/Zr₂O₇ metal oxide nanocomposites are superior photocatalysts. The development of innovative and efficient nanocomposite materials is becoming more and more crucial due to the product's favourable environmental effects. The degradation of methylene blue dye under solar radiation was evaluated in this work using Sn/ZrO₄ and Ce₂/Zr₂O₇ and the obtained data was examined and analyzed.

Experimental

The required chemicals in this study were Zirconyl nitrate (Zr(NO₃)₂·3H₂O), Tin chloride hexahydrate (SnCl₂·6H₂O), Cerium nitrate (Ce(NO₃)₂) and oxalic acid all of which were analytical grade and used without further purification.

Synthesis of zirconium oxide nanoparticles

In order to carry out a single-step hydrothermal synthesis of ZrO₂, 2.61g of zirconium nitrate trihydrate (Zr(NO₃)₂·3H₂O) and 0.24g of NaOH were added to 70 ml of distilled water. The mixture was then stirred with a magnetic stirrer for 30 minutes at room temperature in order to maintain a pH of 7. The mixture was poured into a 150 ml stainless steel autoclave with a Teflon lining and heated to 160°C for ten hours[3-5]. Following the sample's return to room temperature, distilled water and ethanol were used to wash it. In a hot air oven, the product was dried at 80°C.

Synthesis of Sn/ZrO₄ nanocomposite

The standard hydrothermal approach was used to produce the Sn/ZrO₄ nanostructure. To keep the pH level at 7, 1.74 g of zirconium nitrate trihydrate (Zr(NO₃)₂·3H₂O) was added to 40 ml of distilled water, and 0.12 g of NaOH was added to the mixture[6]. To the reaction mixture, 1.13g of tin chloride hexahydrate (SnCl₂·6H₂O) was added. For 30 minutes, the aforementioned combined solution was stirred magnetically and kept at 80°C. The entire mixture was moved into a stainless steel autoclave with a Teflon lining. For ten hours, the autoclave was maintained at 160°C. After that, room temperature cooling was given to the reaction mixture. The synthesized product was kept for later research after being cleaned with ethanol and distilled water, then dried for a whole night at 80°C[7].

Synthesis of Ce₂/Zr₂O₇ nanocomposite

The Ce₂/Zr₂O₇ nanocomposite was created hydrothermally by dissolving 1.74g of zirconium nitrate trihydrate (Zr(NO₃)₂·3H₂O) in 40 ml of water, adding 0.12g of NaOH to 20 ml of distilled water to keep the pH at 7, and agitating the mixture with a magnetic stirrer for 30 minutes at room temperature. The mixture was poured into a 150 ml stainless steel autoclave with a Teflon lining and heated to 160°C for ten hours[8]. Following the sample's return to room temperature, ethanol and distilled water were used to wash it. In a hot air oven, the product was dried overnight at 80°C.

Characterization of ZrO₂, Sn/ZrO₄ and Ce₂/Zr₂O₇ nanocomposite

XRD Analysis

The XRD patterns of the prepared samples after calcination at 500 °C were analysed and the observed diffraction peaks at 2θ values of ZrO₂ nanoparticle were found in the planes of (111), (001) and (131), respectively (JCPDS Card No. 79-1796)[9]. Sn/ZrO₄ nanoparticles are ascribed to the reflection plane of (101), (111) and (200), which matched





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with JCPDS Card No. 48-0889[10]. $\text{Ce}_2/\text{ZrO}_2\text{O}_7$ nanoparticles are ascribed to the corresponding planes of (111), (200), (220) and (131) which confirmed the formation and well matched with JCPDS Card No. 52-1104[11]. These phenomena indicate that the formation of ZrO_2 , Sn/ZrO_4 and $\text{Ce}_2/\text{ZrO}_2\text{O}_7$ nanocomposite began at the calcination temperature of about 450 °C. Peaks are not detected in other phases, indicating the high purity of the products shown in (Fig.1). Crystallite size of ZrO_2 , Sn/ZrO_4 and $\text{Ce}_2/\text{ZrO}_2\text{O}_7$ nanocomposite were calculated by using Debye–Scherrer formula (Equation 1) and the values were presented in Table 1.

Debye–Scherer’s equation

$$\text{Crystalline size (D)} = \frac{0.9\lambda}{\beta \cos\theta} \quad \text{----- (1)}$$

Where λ is the wavelength ($\lambda = 1.5406 \text{ \AA}$ (Cu $K\alpha$)), β is the full width half maximum (FWHM) and θ is the diffraction angle.

FT-IR Spectrum of ZrO_2 , Sn/ZrO_4 and $\text{Ce}_2/\text{ZrO}_2\text{O}_7$ nanocomposite

Analyzing the various functional groups including oxygen-containing functional groups found in metal oxides was made easier with the use of the FT-IR approach. The stretching vibrations of ZrO_2 , as seen in Fig.2a FT-IR spectra, are centered at 569 cm^{-1} due to Zr-O stretching vibrations; the stretching vibrations of C–O and C=O groups found in metal oxide nanoparticles are represented by the peak at 1108 cm^{-1} [12], while the stretching vibrations of H–O–H are indicated by the peak at 3549 cm^{-1} . The stretching mode of the M–O bond is responsible for the stretching vibration peaks at 539 cm^{-1} (Figs.2b and 2c); the stretching of the C–O and C=O groups present in the metal oxide nanoparticles were shown by the stretching vibration peak at 1187 cm^{-1} [13]. The H–O–H stretching vibrations are shown by the peaks at 3547 , 3561 and 3450 cm^{-1} . Because it inhibits charge carrier fusion and has a synergistic effect that increases the nanocomposite’s catalytic activity.

Morphology Analysis of ZrO_2 , Sn/ZrO_4 and $\text{Ce}_2/\text{ZrO}_2\text{O}_7$ nanocomposite

Using SEM micrographs, the surface morphology of the synthesized ZrO_2 , Sn/ZrO_4 , and $\text{Ce}_2/\text{ZrO}_2\text{O}_7$ nanoparticles were examined. The results are shown in Figs. 3a and 3b. Fig.3a depicts the agglomerated structure of the ZrO_2 nanoparticle, whereas Fig.3b shows the uneven form of the Sn/ZrO_4 nanoparticles[14]. $\text{Ce}_2/\text{ZrO}_2\text{O}_7$ nanoparticles were interestingly spherical (Fig.3c) in various directions[15].

UV - DRS Analysis of Sn/ZrO_4 and $\text{Ce}_2/\text{ZrO}_2\text{O}_7$ nanocomposite

Fig.4 displays the results of UV-diffuse reflectance spectroscopy of Sn/ZrO_4 and $\text{Ce}_2/\text{ZrO}_2\text{O}_7$ nanocomposites. The results demonstrate that the UV absorption edge of the pure Sn/ZrO_4 and $\text{Ce}_2/\text{ZrO}_2\text{O}_7$ nanocomposites were significantly noticed at 200 to 800 nm [15]. However, some samples' UV absorption migrated to the higher wavelength side. The band structure alterations are reflected in the variations in the absorption edges. Additionally, the equation for the Kubelka-Munk function is used to compute the bandgap of samples[16].

$$\alpha h\nu = A (h\nu - E_g)^n \quad \text{----- (2)}$$

Where α is the absorption coefficient and $h\nu$ is the incident photon energy. As shown in Fig.5, the bandgap energies are estimated from the intercept of the tangents. The band gap of prepared Sn/ZrO_4 and $\text{Ce}_2/\text{ZrO}_2\text{O}_7$ nanocomposites were found to be 2.5 and 2.0 eV respectively.

Photocatalytic Measurements

The degradation of methylene blue dye solutions, a model organic pollutant, was used to assess the photocatalytic activity efficiency of produced Sn/ZrO_4 and $\text{Ce}_2/\text{ZrO}_2\text{O}_7$ nanocomposite under visible light and sunshine, respectively. In under 60 minutes, the dye breakdown process utilizing solar radiation was completed (Fig.5). In comparison to Sn/ZrO_4 catalyst, the produced $\text{Ce}_2/\text{ZrO}_2\text{O}_7$ nanocomposite has demonstrated a quicker rate of dye degradation[17]. Fig.5a clearly illustrates the Sn/ZrO_4 nanocomposite’s 72.8% methylene blue degradation efficiency, while Fig.5b displays the $\text{Ce}_2/\text{ZrO}_2\text{O}_7$ nanocomposite’s 83.2% methylene blue degradation efficiency after 60 minutes of sunshine irradiation. The effectiveness of the nanocomposites’ degradation was measured in weight percentages using 20 mg of catalyst. The breakdown efficiency of the produced materials under solar radiation is demonstrated in



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Figs.6a and 6b, where it is found that Ce_2/ZrO_2O_7 is more efficient than Sn/ZrO_4 [18]. Every ten minutes, the degradation efficiency was measured, allowing us to deduce that, when exposed to sunlight, the Ce_2/ZrO_2O_7 composite material was more efficient than the Sn/ZrO_4 nanoparticles.

Mechanisms of photocatalysis:

The actual process of methylene blue dye degradation indicates that conduction band electrons (e^-) and valence band holes (h^+) were created when Sn/ZrO_4 and Ce_2/ZrO_2O_7 nanoparticles were exposed to light energy bigger than or equal to their band gap energy [19]. Organic compound oxidation is mediated by the creation of hydroxyl radicals, while reduction and oxidation processes are mediated by the production of superoxide radicals. A schematic illustration of the degradation mechanism is shown in Fig.7 [20-22]. Heterogeneous photocatalysis is produced through the oxidation pathway by the hydroxyl radical that is generated. The dye may be reduced to superoxide radical a Ce_2/ZrO_2O_7 or photogenerated by combining electrons with electron acceptors such as O_2 that is dissolved in water or adsorbed on surfaces. When the photogenerated holes react with OH^- or H_2O , they can oxidize organic molecules by generating OH radicals [23]. The majority of methylene blue may be oxidized by the OH radical into non-toxic byproducts such CO_2 , H_2O , and mineralized product since it is such a potent oxidizing agent [24].

CONCLUSION

The hydrothermal approach was employed to synthesize the nanomaterials viz., Sn/ZrO_4 and Ce_2/ZrO_2O_7 and were calcined at $450^\circ C$ for 6 hours, producing Sn/ZrO_4 and Ce_2/ZrO_2O_7 nanomaterials with a crystalline size of 36.7 and 47.6 nm with the agglomerated matrix and irregular structures. Kubelka - Munk function plot scrutinized that the band gap of Sn/ZrO_4 was 2.5 and Ce_2/ZrO_2O_7 was 2.0 eV, respectively. The photocatalytic performance of the synthesized Sn/ZrO_4 and Ce_2/ZrO_2O_7 nanocomposites against methylene blue dye was evaluated by sunlight irradiation with 20mg of weight percentages of the catalyst. Ce_2/ZrO_2O_7 nanomaterial showed a high degradation property (81.3%) compared to Sn/ZrO_4 materials (69.0%). The sunlight irradiation is a preferable source for eco-friendly photocatalytic degradation processes. The materials were also used for reducing the water pollution via an efficient photodegradation processes.

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Table.1.Crystalline size of ZrO₂, Sn/ZrO₄ and Ce₂/ZrO₂O₇nanocomposite

S.No	Sample	Crystalline Size(nm)
1	ZrO ₂	27.8
2	Sn/ZrO ₄	37.6
3	Ce ₂ /Zr ₂ O ₇	43.2

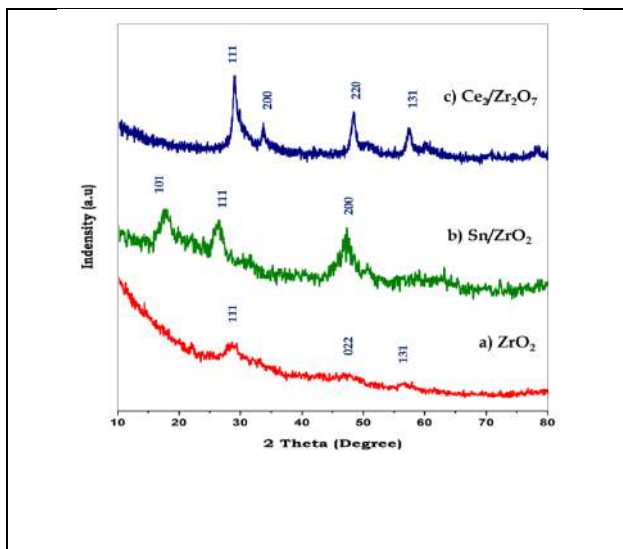


Fig.1 XRD spectra of (a) ZrO₂, b) Sn/ZrO₄ and (c) Ce₂/ZrO₂O₇nanoparticles

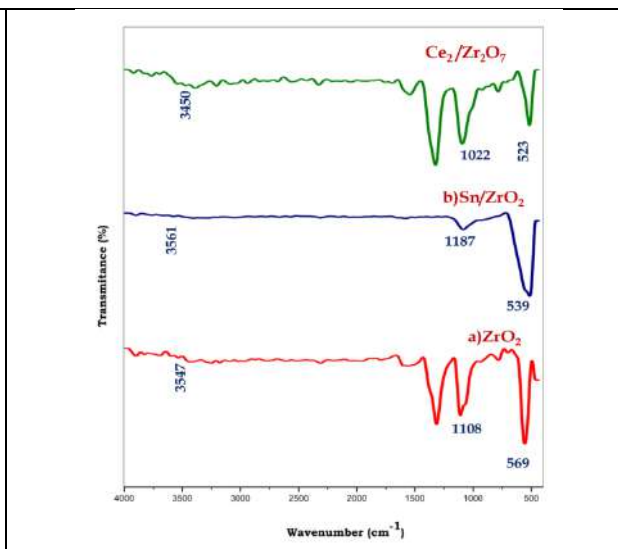


Fig. 2. FT-IR Spectrum of (a) ZrO₂, b) Sn/ZrO₄ and (c) Ce₂/ZrO₂O₇





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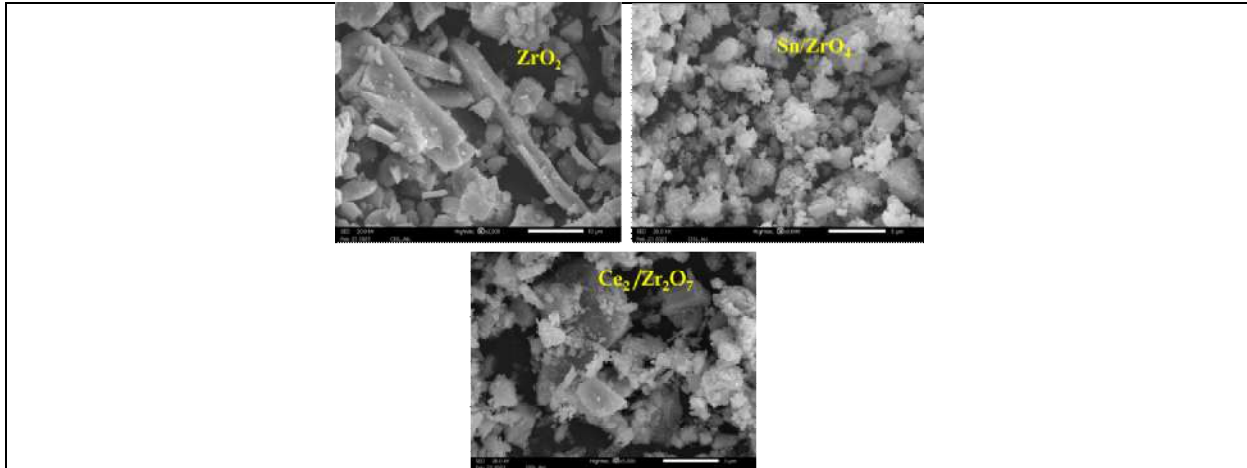


Fig.3SEM analysis of a)ZrO₂, b)Sn/ZrO₄and c)Ce₂/Zr₂O₇nanocomposite

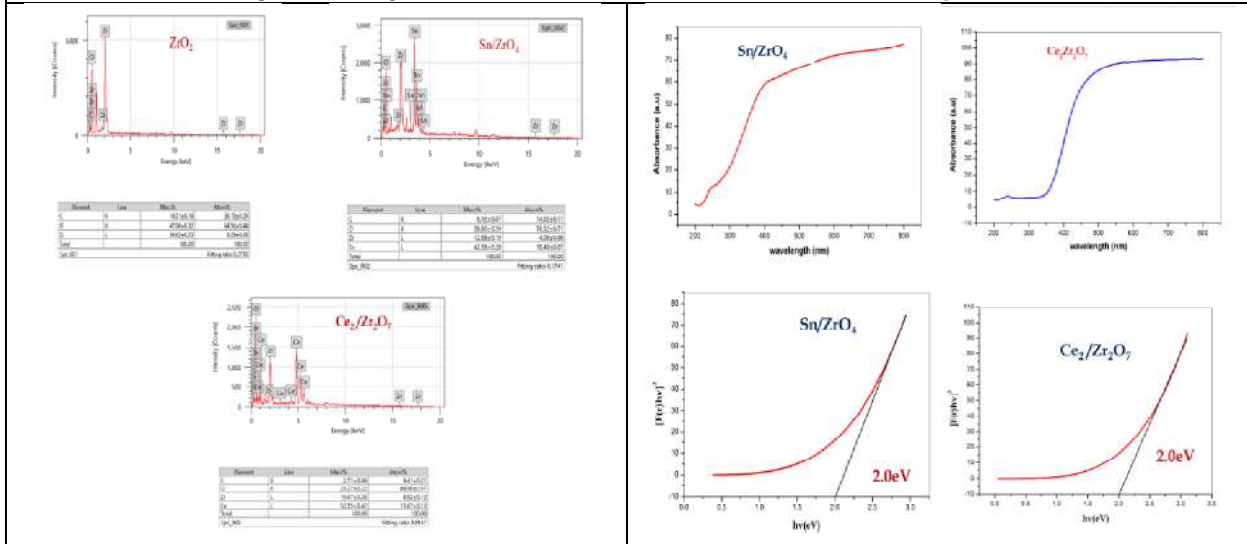
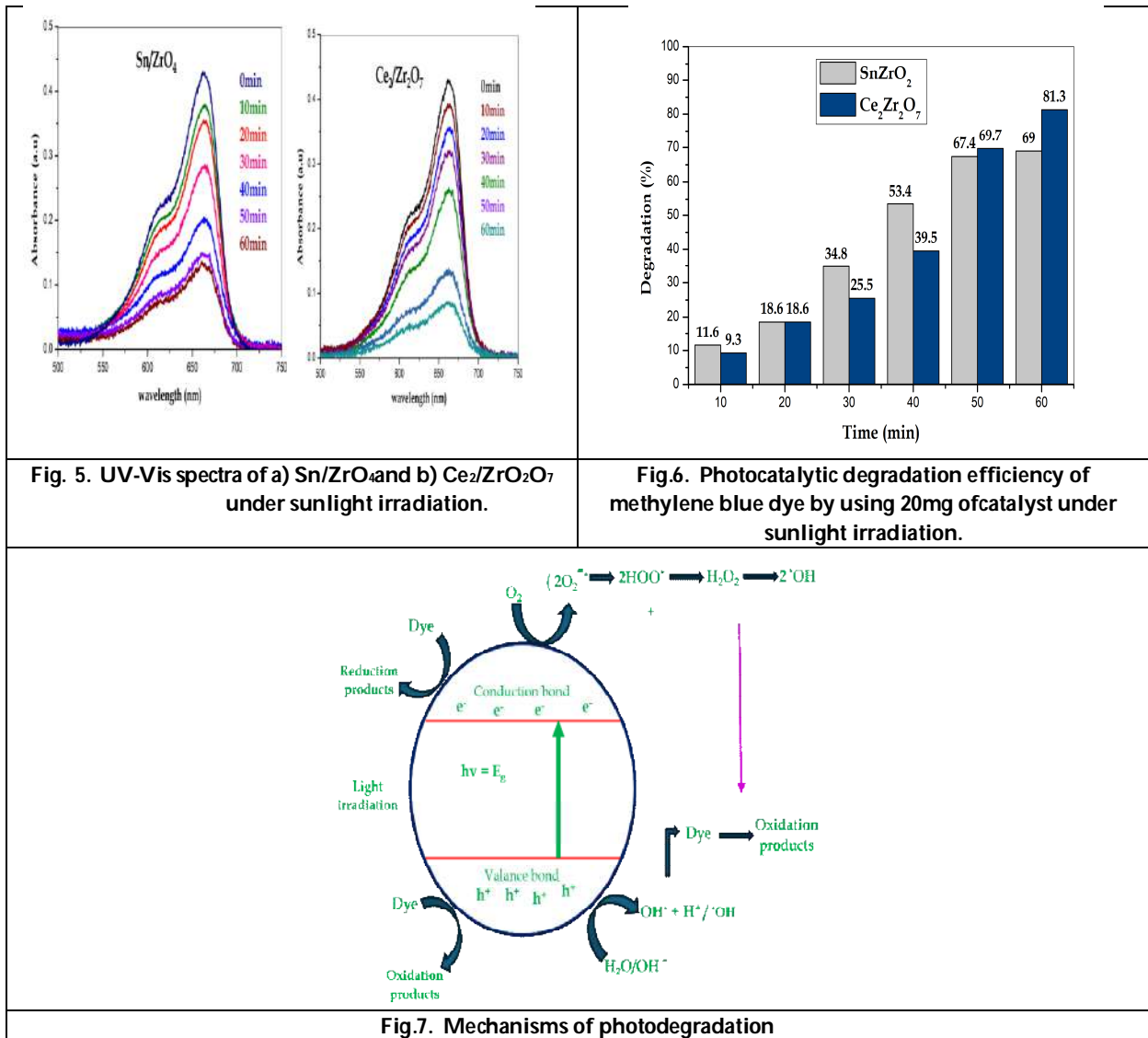


Fig. 4.UV-DRS Image of a) Sn/ZrO₄ b) Ce₂/Zr₂O₇c) Tauc's plot of Sn/ZrO₄ and d) Tauc's plot of Ce₂/Zr₂O₇





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Geospatial based Hydrogeochemical Study of Water Quality in Aizawl District, Mizoram, India

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ABSTRACT

This study is carried out to analyze the hydrogeochemical characteristics of water in the Aizawl District and the uses of GIS techniques called geospatial for identifying the chemical distribution based on the element concentrations. 55 different samples were collected in the Aizawl district during pre-monsoon. The samples were tested/analyzed with different parameters such as pH, EC, TDS, Chlorine, Carbonate, Bi-carbonate, Calcium, Magnesium, Sulphate, Phosphate, Sodium, Silica and Potassium. The spatial variations map has been utilized to identify the quality location within the study area. The spatial chemical distribution map was prepared to analyze the chemical concentration area in the Aizawl district. The study results show that the water quality in most parts of the sampling area is suitable and falls under the permissible limit except in a few locations. This study reveals that the quality of water in the study area is sustainable for domestic usage, agriculture, and different purposes.

Keywords: GIS, Water quality, Hydrogeochemistry, Groundwater, Aizawl District.

INTRODUCTION

Water is an extremely valuable natural resource, and in the last year, there has been less fresh water available on the surface. Water is a more dynamic renewable resource, but it is still very important to have access to it when and where it is needed in acceptable quality and sufficient quantity. The demand for water supply increases rapidly due to urbanization, the growth of population, and extensive use in domestic and agricultural sectors (Chaudhary et al.,



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1996). As a result, conducting a quality analysis and detecting potential hazards is essentially important to meet the demand for a clean water supply to the present civilization. Groundwater is an essential natural resource for providing reliable and economical potable water supply in both urban and rural areas. Therefore, it plays a crucial role in human well-being as well as that of aquatic and terrestrial ecosystems (Sar et al., 2015). Geologically, Mizoram state comprises N-Strending ridges with high degree of slopes and narrow intervening synclinal valleys, faulting in many areas has produced steep fault scarps (GSI (2011)). In hilly areas like Mizoram, even though the rainfall is comparatively high, shortage of water is often experienced in the post-monsoon season, as most of the water available is lost as surface runoff (Lalbiakmawia, 2015). Groundwater stored in the hill slopes emanates in the form of springs, which are being used as a source of water supply (CGWC, 2013). Recently, Geographic Information Systems (GIS) and Remote Sensing techniques set a new challenge in mapping the chemical distribution in the field of hydrogeology. It also has a wide range of applications in the field of geosciences. Geographic information system (GIS) and remote sensing (RS) tools are widely used for the management of various natural resources (Krishna Kumar et al., 2012, Magesh et al., 2011). The field of geospatial technology holds immense potential for studying water resources. As a result, numerous researchers have effectively applied these methodologies in groundwater studies (Krishnamurthy et al., 2000, Saraf. A. K & Chaudhury P. R., 1998). Hydrogeology and the development of water resources have demonstrated the enormous significance of these similar procedures (Saraf. A. K & Chaudhury P. R., 1998). The main objective of the present study is to illustrate several thematic maps and spatial maps to demonstrate the chemical distribution of water in Aizawl district and to provide a vital database for future hydrochemical studies within the district.

MATERIALS AND METHODS

Study area

Aizawl district is located in the northeastern part of Mizoram. It is bounded on North and North-east by Kolasib district of Mizoram and parts of Manipur, South by Serchip district, East by Champhai district and west by Mamit district of Mizoram (GSI, 2011). It covers an area of 2138.62 sq. km, and the district is divided into four Rural Development (RD) block. Geographically the Aizawl district is located in 23°18'24.04" N to 24°24'47.23 N latitudes and 92°37'27.62" E to 93°02'26.71" E longitudes. It falls under Survey of India toposheet No. 83D/15, 83D/16, 84A/9, 84A/10, 84A/11, 84A/13, 84A/14, 84A/15, 84E/1, 84E/2, 83H/3 and 83H/4. The climate of the study area ranges from moist tropical to moist sub-tropical (Lalbiakmawia, F., 2015). The district receives heavy rainfall during May to late September with an average annual rainfall of 2,794 mm under the influence of southwest monsoon (CGWC, 2013). The location map of the study area is shown in Figure 1.

Geomorphology of the study area

Geomorphologically the district is characterized by ridgelines and intervening valleys; the landscape is mountainous with notable relief from a physiological perspective and the hill ranges are trending in the north-south direction. Deep gorges are created by synclinal narrow valleys running parallel to subpar anticlinal hill ranges. The primary geomorphic units are structural hills, which are classified as high, moderate, and low structure hills according to elevation. Structural hills, as their name suggests, are formed structurally and are connected to faulting, folding, and other tectonic processes (Lalbiakmawia & Vanthangliana, 2015). Other geomorphic units include the Alluvial Plain and Intermontane valley (Lalbiakmawia & Lalbiakmawia, 2016).

Geology of the study area

The earliest recorded work on the geology of Mizoram was conducted in 1891 and it was reported that the area consisted of great flysch facies of rocks comprising monotonous sequences of shale and sandstone (La Touche THD, 1891). The research area is surrounded by the Tertiary Bhuban and Bokabil formations of the Surma Group, which are primarily composed of argillaceous and arenaceous rocks (GSI, 2011). The Surma group is comprised of the Bhuban and Bokabil Formations, the most developed lithounit in the Surma Basin with a thickness of 5000 meters. Again, the Bhuban Formation is subdivided into Lower, Middle and Upper Bhuban units, Upper Bhuban Formation comprises of an arenaceous succession predominating with sandstone, shale and siltstone (Bharali et al., 2017).



**Krista Lalnarammawia and Paluchamy Anandhan****Drainage system of the study area**

Aizawl district is drained by Tlawng river in the west and Tuivawl river in the east, also Tuirial river drain in the mid part of the district. These major rivers flow in south-north direction throughout the district. Tuivawl and Tuirial river flows in a northward direction till it enter Cachar district in Assam and confluence Barak River in Assam. Tlawng river on the other hand flows northward and enter Kolasib district in Mizoram till it enters Assam. The streams are young stages with deep courses, and the majority of the drainage follows a dendritic to sub-dendritic pattern. Numerous tributaries can be found along the drainage pattern of the major drainage.

Arc-GIS Software 10.8.2 and QGIS

The GIS software ArcMap and QGIS were used to generated several thematic maps including the Geology, Geomorphology, Drainage and Spatial Interpolation map. Arc-GIS spatial analyst consist of numerous interpolation tools. Inverse Distance Weighed (IDW) is the selected tools for this study. The sample points are weighed during interpolation in the IDW interpolation method.

Data analysis

Water samples are collected from 60 different locations and tested for their physio-chemical parameters. The base map was digitized using QGIS software and exported to ArcMap 10.8.2 software for spatial analysis. The chemical characteristics of the water are evaluated using the Indian Drinking Water Standards as per BIS. The major parameters used for analysis are pH, Electrical Conductivity (EC), Total Dissolved Solid (TDS), Chloride, Carbonate, Bi-carbonate, Calcium, Magnesium, Sodium, Potassium, Silica and Phosphate. Spatial interpolation technique such as Inverse distance weighed (IDW) are used for generating spatial distribution of water quality in this study. The spatial variation maps of the major water quality parameters were produced as a thematic layer following BIS guideline. This guideline categorized each ground water parameters as desirable limit, permissible limit and non-potable classes. The different classes within the BIS Guideline were represented in the present study as good, moderate and poor classes respectively (Lalbiakmawia & Vanthangliana, 2015).

RESULTS AND DISCUSSIONS

The water quality attribute database is used to generated the spatial variation layer of the major water quality parameters. Based on the spatial variation layers of major water quality parameters, an integrated water quality map of Aizawl District was prepared using the GIS software. The minimum, maximum and average value of the parameters is shown in table 1. The results and discussion for the major parameters are as follow.

pH

pH is an essential water parameter that indicates its level of acidity or alkalinity. The pH value of water ranges from 6 – 9. The activity of hydrogen ions, represented in logarithmic units, is referred to as pH. Chemical reactions that generate or consume hydrogen ions regulate the activity of hydrogen ions. The pH values of the sample are classified into two classes poor and good classes based on BIS standard. Almost all the sample in the study area are falls into a desirable limit based on BIS guideline (6.5 – 8.5). The average pH concentration in the study area is 7.1. A few locations have a pH value lower than 6.5 and few sample location has a pH value higher than 8.5. The area where the pH value falls into desirable limit were categorized as good class while those area with pH value lower and higher were categorized as poor class. The spatial variation map for pH is shown in Figure 2.

Electrical Conductivity (EC)

The capacity of a material to carry electric current is known as Electrical Conductivity (EC). The conductivity measurement is directly correlated with the water's strength. The EC for the purest water is 0.05 $\mu\text{s}/\text{cm}^2$. Based on the BIS guideline, the value of EC for all the sample falls under desirable limit. The spatial variation of EC is illustrated on Figure 3. The sample is classed into three classes low, moderate and high. The average concentration of EC in the



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region is 200.77 $\mu\text{s}/\text{cm}^2$. As shown in figure majority of the sample have low concentration of EC and few sample have higher concentration.

Total Dissolved Solid (TDS)

As per BIS guideline the Total Dissolved Solid is Classified into three ranges (0-500 mg/L, 500 – 2000 mg/L, > 2000 mg/L). Nevertheless, all the sample in the study area falls under desirable limit, the TDS concentration in the region ranges from 11.00 mg/l to 411 mg/l, with an average concentration of 102.01 mg/l. The spatial variation map of TDS is shown in Figure 4. Majority of the sample have low concentration of TDS while only few samples are categorized in high concentration. The TDS value are higher in the southern part of the study area and also in the central part of the area. It is true that a rapid determination of total dissolved solids in groundwater can be made by measuring the electrical conductance. This is because the total dissolved solids (TDS) in water increase the electrical conductivity of the water. Therefore, by measuring the electrical conductance of the water, we can estimate the TDS concentration. However, while this method is relatively quick and easy, it may not provide accurate results in all cases and may require additional testing to confirm the TDS concentration.

Chloride (Cl)

Chloride in high concentration led to water a salty taste. Based on BIS guideline the acceptable limit of chloride in water is 250 mg/l. However, all the samples collected are falls under desirable limit. The chloride concentration of the sample in the study area ranges from 17.725 mg/l to 168.387 mg/l with an average concentration of 37.36 mg/l. In Figure 5, we can see that the chloride concentration is high in the northern part and southern part of the region, and also the high in the area with higher population like city or town which is in the central part of the study area.

Sulphate (SO₄)

High concentration of sulphate in drinking water can affects its taste and odour. Sulphate occurs naturally in groundwater due to dissolution of minerals. The maximum acceptable limit is 200 mg/l. Water containing about 500 mg/l of sulphate taste bitter; water containing about 1,0000 mg/l may be cathartic. The study shows the concentration in the region ranges from 37.108 mg/l to 64.705 mg/l. The average concentration in the region is 51.00 mg/l. However, the study area shows no concentration higher than the acceptable limit provide by the BIS guideline. The spatial variation map for sulphate is shown in Figure 6. It is classified into low, moderate and high. The figure shows that the northern part of the region has a high concentration of sulphate and the majority of the samples have a moderate concentration of sulphate in the region.

Phosphate (PO₄)

Phosphate is a critical parameter in water quality analysis as it can have significant implications for aquatic ecosystems. Phosphates are compounds containing the PO₄³⁻ ion and are often found in fertilizers, detergents, and other sources. Groundwater often has low value due to strong absorption of phosphate molecules in soils. The concentration of phosphate in the study area ranges from 1.799 mg/l to 62.283 mg/l. The average concentration in the region is 7.26 mg/l. Again, the spatial map has been classified into three low, moderate and high, which is illustrated in Figure 7. The spatial variation map shows that majority of the samples have low concentration of phosphate, while few samples are classified into moderate and high concentration.

Calcium (Ca)

Calcium is a major contributor to water hardness, which is a measure of the concentration of divalent cations (primarily calcium and magnesium) in water. 75 mg/l in water is the acceptable limit as per BIS guideline. The spatial variation of calcium in the study area is shown in Figure 8. Here, it is classified into three classes based on the concentration i.e., low, moderate and high. The concentration of the calcium in all the sample falls under acceptable limit, and the concentration ranges from 4 mg/l to 34mg/l with an average concentration of 14.70 mg/l. There is a lower concentration of calcium in the southern part of the study area, with most samples showing a moderate concentration of calcium.



**Krista Lalnarammawia and Paluchamy Anandhan****Magnesium (Mg)**

Magnesium is a key contributor to water hardness, alongside calcium. The concentration of magnesium generally less than 50 mg/l in continental water. The result shows very low concentration ranging from 2.4 mg/l to 15.6 mg/l. The average concentration in the study area is 5.56 mg/l. The BIS guideline determined that the acceptable limit of calcium in drinking water is 30 mg/l. This shows that all the samples in the study area falls in acceptable limit. The spatial variation map classified the region into three classes low, moderate and high based on the analyzed concentration, which is shown in Figure 9. The majority of the sample falls into low concentration classes, while few sample have high magnesium concentration.

Silica (H₄SiO)

Silica, which refers to the oxide SiO₄, is a commonly used term for silicon in natural water. However, the actual form of silica is hydrated and is more accurately represented as H₄SiO or Si(OH)₄. The dissolved silica in natural water is generally a result of the chemical breakdown of silicate minerals during the process of weathering, which is irreversible. In this study the region in classified into three group low, moderate and high based on the concentration, the spatial variation is shown in Figure 10. The concentration of silica in the region ranges from 4.8 mg/l to 138.6 mg/l with an average of 49.50 mg/l. The map shows that the southern part of the study area has low concentration of silica while the northern part of the study area has moderate concentration, few sample have high concentration of silica based on the spatial classification.

Sodium (Na)

Sodium is a common element found in water, and its concentration is often measured in water quality analysis. The presence of sodium in water can have various sources, including natural weathering of rocks, industrial discharges, and human activities. The sodium concentration in the study area ranges from 0.9 mg/l to 106 mg/l. The average concentration is 17.65 mg/l. The spatial distribution map shows that the concentration of sodium is high in the northern part of the region. Majority of the samples consist of low sodium concentration. The spatial distribution map is illustrated in Figure 11.

Potassium (K)

Potassium is a naturally occurring element that can commonly be found in rocks, minerals, and soils. It can enter water sources through the natural breakdown of rocks and minerals, as well as through the weathering process. The use of fertilizers containing potassium can also lead to elevated levels of this element in water bodies through runoff. Different countries and regions may have their own specific standards or guidelines for water quality regarding the presence of potassium in both drinking water and surface water. Elevated levels of potassium in water can have a negative impact on aquatic ecosystems. Excessive amounts of potassium may lead to nutrient imbalances, which can affect the growth of aquatic plants and algae. Additionally, some industries may release potassium into water as part of their effluents. This study classified the potassium concentration into three classes i.e., low, moderate and high respectively, which result that the majority of the samples in the region have low concentration. The spatial distribution map shown in Figure 12, which shows that the southern part of the study area has higher concentration compared to the other part of the region in the study area.

Bi-Carbonate (HCO₃)

Bicarbonate is typically produced by the weathering of silicate and carbonate, as carbonate mineral is not very soluble in pure water. The carbonate forms a calcium carbonate scale that limits the flow of fluids in pipes and slows the movement of heat through pipe walls when it mixes with alkaline earth elements, primarily calcium and magnesium. Alkalinity is a crucial component in determining how much lime and soda ash are needed to soften water, as well as a crucial component in corrosion prevention. The value of bi-carbonate in the study area ranges from 24.4 mg/l to 347.1 mg/l with an average value of 6.22 mg/l. Fig. 13 shows that the central part of the study area has higher concentration of bi-carbonate while north part has low concentration.





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CONCLUSION

The hydrogeochemical analysis results shows that the dominant ion in the region is Bi-carbonate (HCO_3^-) and is also the dominant cation while Sodium (Na^+) is the dominant anion. The geochemical analysis reveals that the majority of geochemical facies of the water samples are dominated by HCO_3^- - Cl^- - Na^+ - SO_4^{2-} - PO_4^{3-} - Ca^{2+} - K^+ - Mg^{2+} types of water. The use of GIS software such as ArcGIS make the water quality analysis easier in understanding and identifying the high intensity area of the study. The water quality maps provide better understanding in the existing water condition in the study area. The study results shows that the water quality of all the sample in the study area are in good conditions and falls under permissible limit recommended by BIS guideline except for pH in which pH value of few samples falls out the permissible limit. Therefore, the quality of water in the study area is sustainable for domestic usage, agriculture, industries and different purposes.

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Table.1. Minimum, Maximum and Average values of Parameters.

	pH	EC	Cl	Ca	Mg	HCO ₃	PO ₄	SO ₄	Na	K	H ₂ SiO ₄	TDS
MIN	6.01	23	17.725	4	2.4	24.4	1.799	37.108	0.9	0.1	4.8	11
MAX	9.92	882	163.387	34	15.6	347.1	62.283	64.705	106	20.5	138.6	411
AVG	7.1	202.25	39.315	16.07	6.22	109.66	7.90	54.328	17.76	2.50	54.60	96.78

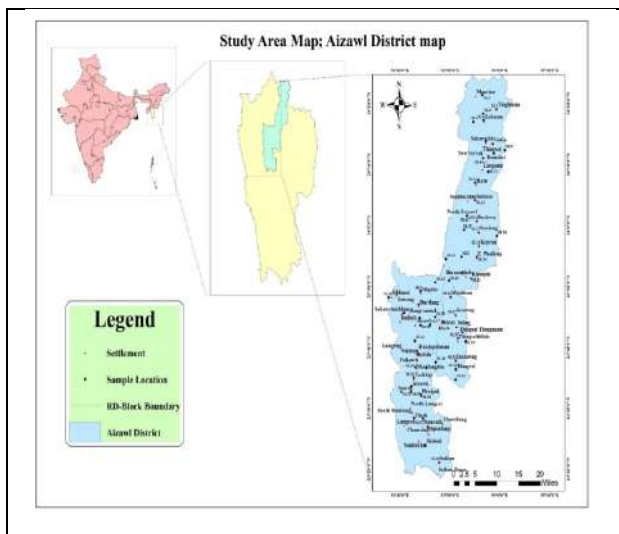


Figure 1. Study area; Aizawl district map

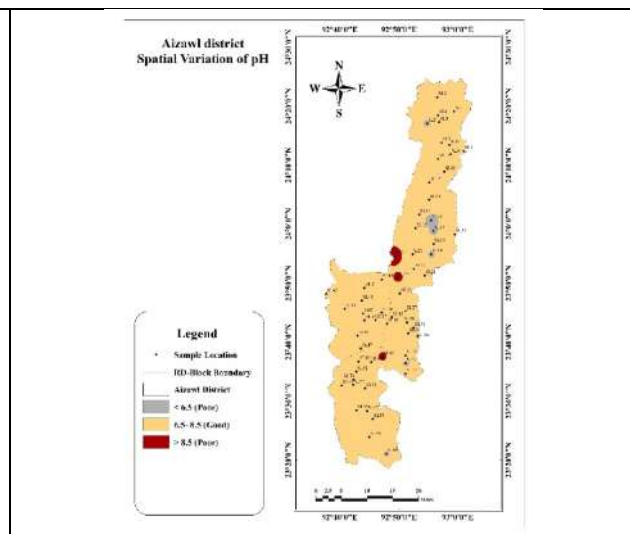


Figure 2. Spatial variation map for pH in Aizawl district

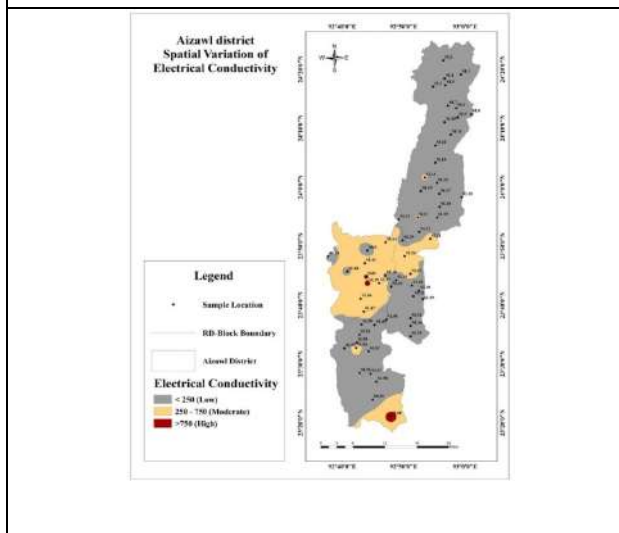


Figure 3. Spatial variation map for Electrical Conductivity in Aizawl district

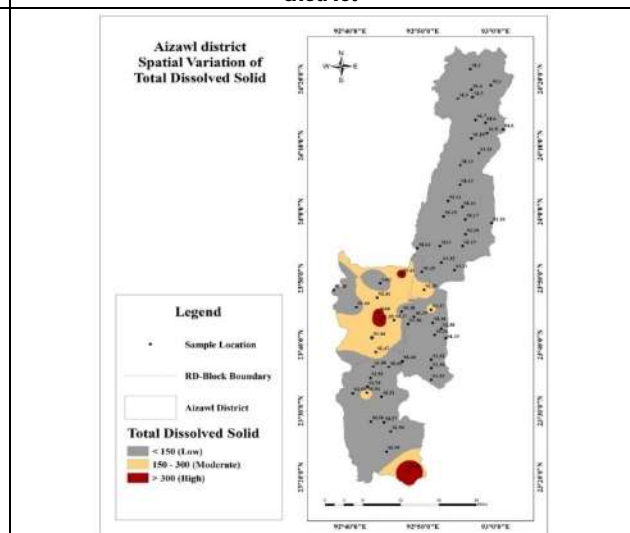


Figure 4. Spatial variation map for Total Dissolved Solid in Aizawl district





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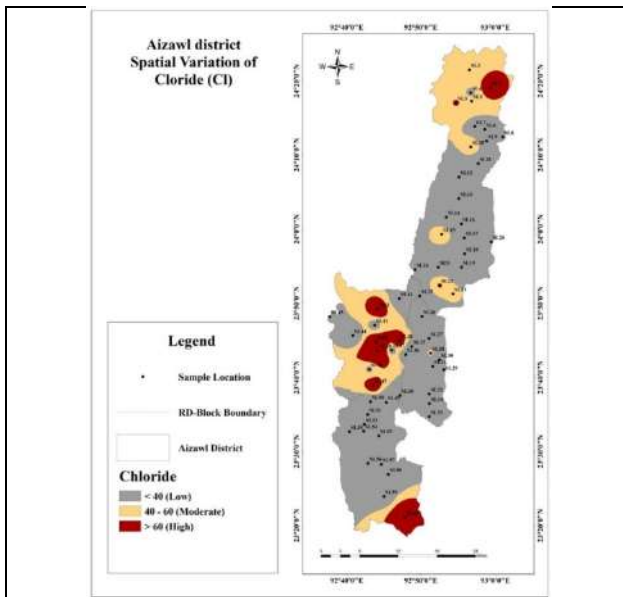


Figure 5. Spatial variation map for Chloride (Cl) in Aizawl district

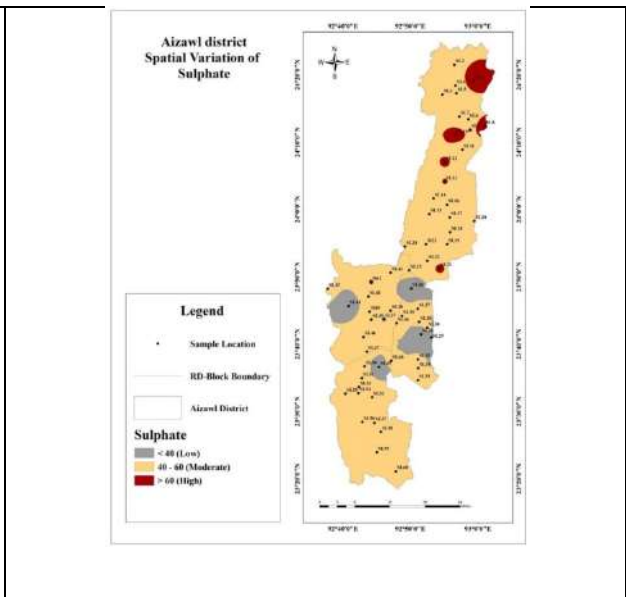


Figure 6. Spatial variation map for Sulphate in Aizawl district

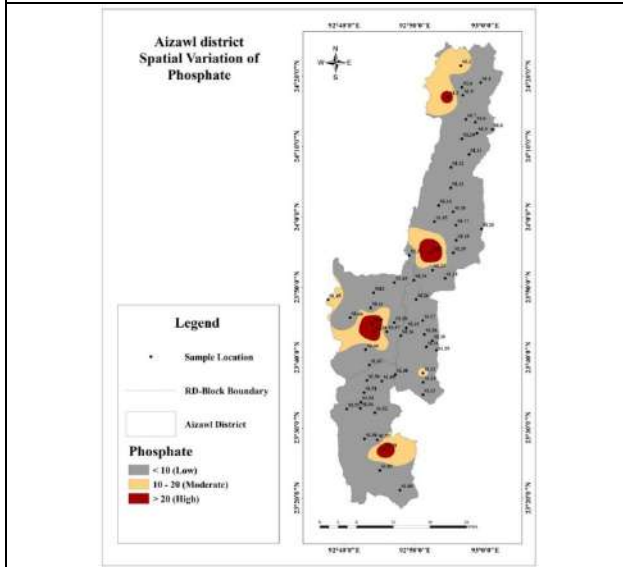


Figure 7. Spatial variation map for Phosphate in Aizawl district

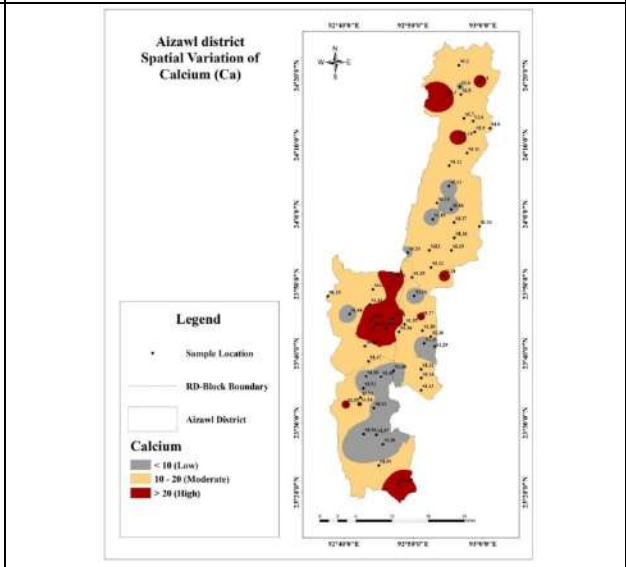
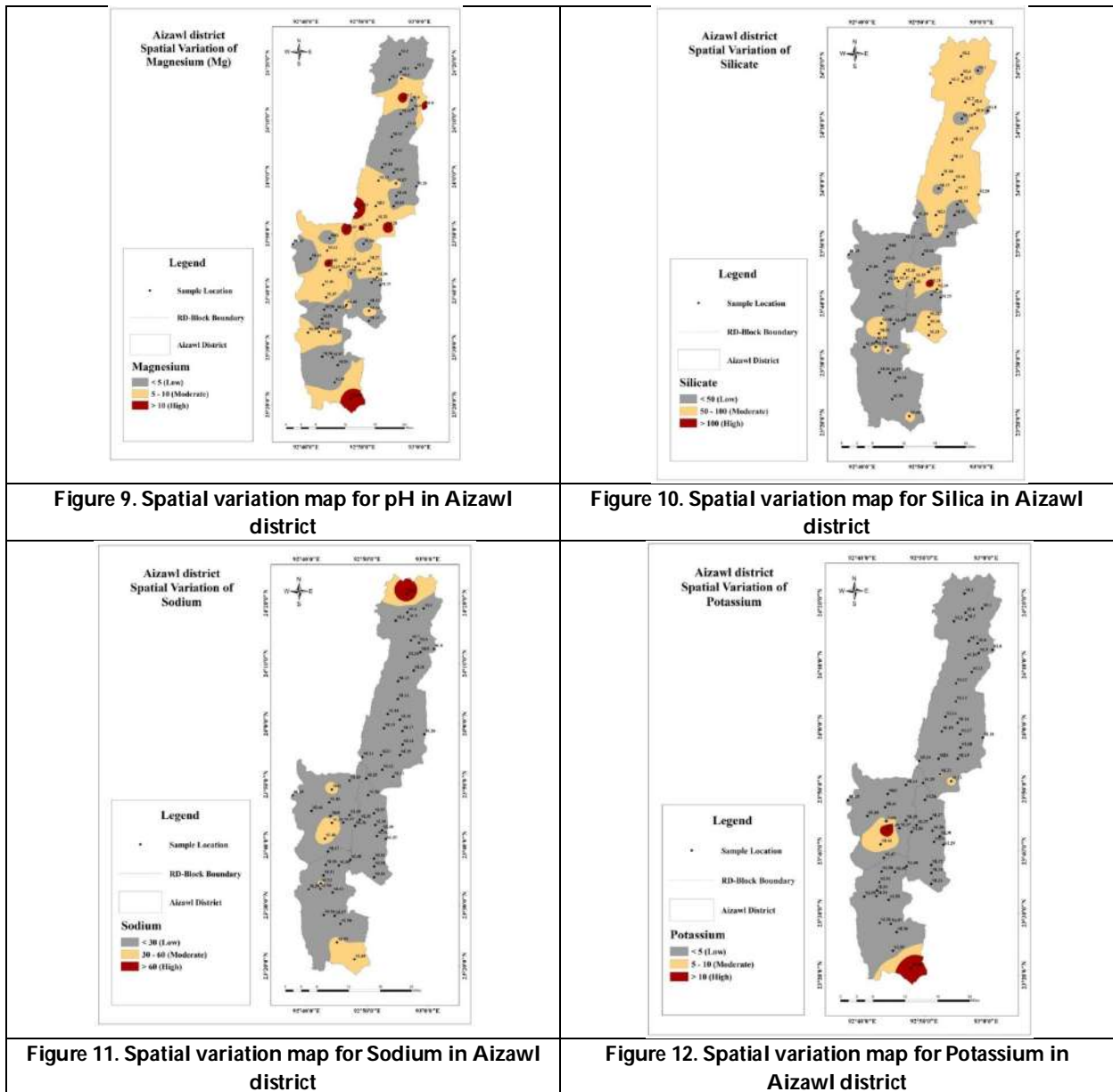


Figure 8. Spatial variation map for Calcium in Aizawl district





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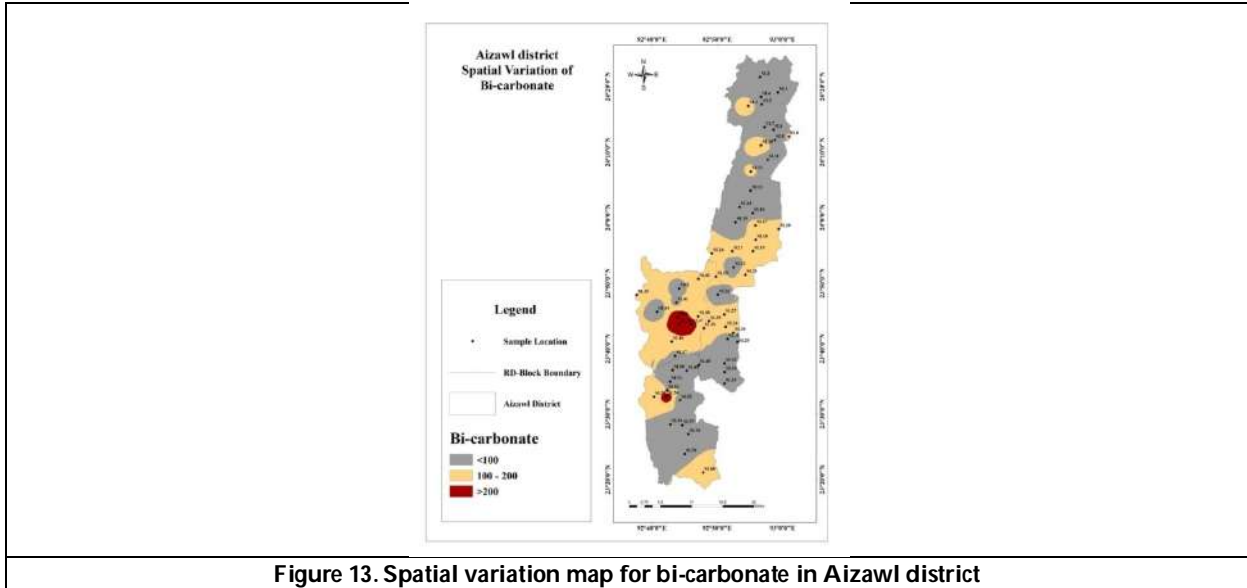


Figure 13. Spatial variation map for bi-carbonate in Aizawl district





Ayurvedic Management of Vicharchika - A Case Study

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ABSTRACT

Vicharchika is among the *Kshudrakushtha* described under the term *Kushtha*, where most skin diseases are mentioned as per Ayurvedic texts. *Kushtha* are the conditions involving *Rakta dhatu* and *Tridosha* which mainly affect the skin in general and form various impairments. Although *KshudraVyadhis* do not significantly impact the body, the patient's mental state is disturbed by their emergence because the ailment is difficult for the patient to recover from. They are extremely challenging to treat because of their high recurrence rate. In this case study we discuss the Ayurvedic treatment given to a female patient, age 37, of *Vicharchika* who had classic symptoms including *kandu*, *strava*, *rukshata*, and *shyavata* on both surfaces of her palms, fingers, and dorsal surfaces of her feet for 4 months. The patient was cured with notable results after one and a half months of treatment after the treatment regimen was followed by the pathophysiology of the condition. The patient was instructed to follow restrictions for a significant diet to prevent recurrence. Overall, repeated *shodhana* with *shamana* medications plays an important role in the speedy recovery of the condition.

Keywords: *Vicharchika*, *Sadyo Vamana*, *Koshthashodhana*, *Shamana*





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INTRODUCTION

Skin is the reflection of the well-being of the person as there may be impairment in lustre, texture or normalcy of skin due to any physical, mental and behavioural disturbances. Skin diseases range from a small spot, discolouration, scar mark or wound to covering the entire body and various lesions. As per the Ayurvedic texts, a major portion of skin diseases is discussed under the heading of *Kushtha* where *Maha kushtha* and *Kshudrakushtha* are two types. The meaning of the word *Kushtha* is "*Kushnati sarvam vapuhu iti Kushta*"—the one who alters the body disgracefully, makes one's skin appear unattractive or ruins the skin texture. Despite the difference in area, severity and prognosis, both equally disturb the mental status of the patient due to the direct appearance on the skin itself.[1] Based on the *Amshamshakalpana* of *Dosha-Dushya*; *Kushtha* is divided into seven types of *Mahakushtha* and eleven types of *Kshudrakushtha*. *Vicharchika* is one among the *Kshudrakushtha*, having *Kandu*, *Pidika*, *Shyava varna*, *Bahustrava*, *Raji*, *Rukshata* and *Ruja* as the classical symptoms and described as *Kapha-Pitta pradhana tridoshaja vyadhi* by Acharyas. In the *Samprapti*(pathogenesis) of *Vicharchika*, there is involvement of *Saptadushyai*.e., *Tridosha*, *Twak*, *Rakta*, *Mamsa* and *Lasika*. [2] *Vicharchika* is commonly found recently, this ailment is upsetting since it results in deformity by impacting a person's appearance cosmetically. Additionally, it has an impact on the quality of life of a person and also due to a high recurrence rate raises economic burden. [3] *Kushtha* is described as *Dushchikitsyavyadhi* as it has more elements in pathogenesis and amount of vitiation and deep-seated *dosha*. As per Ayurveda *Shodhana*(purificatory therapy) is the prime treatment measure and can be applied with *Shamana*(alleviation therapy) and other dietary and behavioural restrictions. A case study of *Vicharchika* is discussed with *Vamana*, *Koshthashodhana* and *Shamana* treatment explained.

Case study

A 37-year-old female patient visited O.P.D., Parul Ayurveda Hospital, having complaints of Itching, scaling, and watery discharge from skin lesions over both palms, fingers and toes with brownish-red discolouration and occasional bleeding from lesions for 4 months. Due to these complaints, her day-to-day household work gets disturbed. There are mental disturbances like excessive thoughts and stress related to the disease condition also found due to repeated occurrences of skin disease. She was previously treated for such skin-related complaints over her abdomen and both upper limbs for 1 year. No significant family history or occupational history was found. The patient was examined and diagnosed with *vicharchika* having classical symptoms like *Shyavata*, *Rukshata*, *Kandu*, *Strava* and *Ruja* and was admitted to the Panchakarma department of Parul Ayurveda Hospital after counselling regarding the *Shodhana* treatments. Other details of patient-related to this case study are as below:

Associated complaints: Burning sensation in the chest, and abdomen occasionally

Past history

- H/O Bell's palsy (5 years back)
- No H/O DM, HTN

General examination

BP: 120/70 mm of Hg

Pulse: 72/min, regular

R.R.: 18/min

H.R.: 74/min

Mala: *Vibandhit*(Habitual constipation)

Mutra: *Samyak pravrutti*, 4-5 times/day

Nidra: Sleep disturbed due to itching

Jihva: *Ishat Lipta*

Koshtha: *Krura*

Agni: *Vishamagni*





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Systemic examination

Cardiovascular system – On Auscultation, normal S₁S₂ heard
Respiratory system – On Auscultation, AEBL clear
GIT – On Palpation, Soft and non-tender abdomen
CNS – NAD, Patient is conscious & well-oriented.

Local examination

Shape – Irregular
Size – Not specific, Covered whole both palms, both toes
Colour – Brownish red
Secretion – Present
Pain – Present occasionally
Inflammation – Present
Loss of sensation – Intact

Sampraptighatak

Dosha – Kaphapradhan Tridosha
Dushya – Rasa, Rakta, Mamsa, Lasika
Srotas – Rasavaha, Raktavaha, Mamsavaha, Svedavaha
Srotodushiti – Sanga
Ama – Sama
Udbhavasthana – Amashaya
Vyaktisthana – Tvacha
Rogamarga – Bahya
Sadhyasadyata – Kricchrasadhya

OBSERVATIONS & RESULTS

In the present study, 1-time classical *Vamana karma* concerning *Shodhana karma* and 2-time *Sadyovamana karma* as repeated *Mrudu Shodhana* measure was conducted, findings are as below.

DISCUSSIONS

As per the classics *Kushtha* is described as *Deergharoga*(deep-seated disease) and included in *Ashta Mahagada*(major diseases) announces the difficulties in the management of particular conditions. *Shodhana* is the main line of treatment in *Kushtha* because *Bahu dosha Avastha*, *Vicharchika* being a *Kshudrakushtha* can be treated with the same principles. By considering the *bala*(strength) of the patient and the amount of vitiated *Dosha*, repeated *shodhana* at regular intervals i.e., *Vamana*(emesis) – once in 15 days, *Virechana*(purgation) – once in a month, *Nasya*(nasal drops) – once in three days, *Raktamokshana*(bloodletting) – once in six months to be conducted.^[8] After the *Shodhana* treatment, *Shamana* also plays an important role in subsiding the remaining *dosha*. *Pathayaahara*(wholesome diet) is essential to prevent recurrence.

Koshthashodhana

The elimination of aggravated *Doshas* and *Mala* present at *Koshtha* is quoted as *KoshthaShodhana*. *Koshthashodhana* refers to *Mrudu virechana* without *Snehapana*.^[9] *TrivrutAvaleha* is chosen for the *Koshthashodhanakarma*, which causes *Pitta-Kaphadosha nirharana* and by its *Snighdhaguna* decreases *Shyavavarna* and *Rukshata* associated with *vata dosha*.^[10] *Triphala Kashaya* acts as *Virechanopaga*.





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Pachana

Before any *Shodhana karma* or *Snehapana*, to obtain *Niraamata – Deepana*, *pachana* is necessary for correcting the status of *Agni*(digestive fire) by which proper digestion of *Sneha* or *Aushadhi* can be achieved.[11]*Chitrakadivati* is used for *Amapachana* and removal of *Pichhilaguna*, it promotes *Jatharagni*, which in turn stimulates all other *Agnis*. [12]*Vasaguduchyadi Kashaya* has ingredients like *vasa*, *Guduchi*, *Triphala*, *katuki* and *bhunimba* which will act on the *sama pitta* and normalize the function of *agni*. [13]

Parisheka

Parisheka is a *Drava sveda* acts on *Pitta-Kapha dosha*. *Panchavalkalakwath* have qualities of *Kaphapittaghna*, *Varnya*, *Vranashodhana*, *Ropana*, *Daha shamana* and *Raktadoshahara* according to *Guna Karma* of drugs. It is also phytochemically rich in phenolic group elements like tannins and flavonoids, which are primarily responsible for its exceptional antiseptic, anti-inflammatory, immune-modulating, antioxidant, antibacterial, antimicrobial, and wound purifying as well as healing. [14]*Panchakola Kashaya* will act by performing *pachana* of the *dosha* present in the *shakha*, thereby removing the *srotorodha*(obstruction). [15]

Abhyantarasnehapana

Shodhananga and *Shamanangasnehapana* used here as *Purvakarma* during the treatment. *Shodhananga Sneha* is given before classical *Vamana karma* in *Bahumatra*(maximum amount) to liquefy the *dosha* and move from *Shakha* to *Koshtha*. Whereas *Shamananga Sneha* is given before *Sadyovamana karma* in *Alpamatra*(minimal amount) for *Pachana* of *Shesha* (remaining) *dosha* and to maintain the status of *Agni* at intervals. Various potent phytoconstituents isolated from *Mahatiktakaghrita* work together to heal *Kushtha*, presumably via the liposomal drug delivery system. [16]

Vamana

Vamana as a prime measure for *Kapha dosha* eliminates *Srotosanga*, expels out the morbid *Dosha* from *Koshtha* and thus does *Sampraptivighatana*(breaking of pathogenesis) of *Vicharchika*. *Vamana* followed by *Purvakarma* helps in reducing symptoms like *Kandu*, *Strava* and *Ruja* in this case by *Kushthaghna*, *Varnya*, *Kandughna* and *Raktashodhaka* properties of drugs used in *Vamana karma*. Probably it leads to cellular-level changes responsible for the reduction of pathogenesis causing the ailment. [17] *Sadyovamana* is planned for the prevention of further accumulation of *Dosha* and chances of recurrence, according to *Bala* of the patient. [18] *Yashtimadhuphanta* is used as *VamanaDravya*. *Yashtimadhu* is included in *Vamanopaga* and *Kandughna mahakashaya* by *Acharya Charaka* which eases the *Vamana* and acts as *Pitta*, *vata*, *raktadoshahara*, also experimentally proven to have anti-tussive & expectorant activity, antioxidant activity, anti-inflammatory activity and immune stimulatory effects. [19]

Shamana chikitsa

KaishorGuggulu works as *Deepana*, *Pachana*, *Kledashoshaka*, *Tridoshashamaka* and by *Rasayana*(rejuvenation) effect it supports *Uttarottara Dhatu Pushti*. [20] *Manjishta* possesses anti-inflammatory, antibacterial and healing qualities for wounds. *Manjishthadighanavati* directly targets the *Rasa*, *Rakta* and *Mamsadhatu* and having *Raktaprasadaka* property also enhances the effect of *KaishorGuggulu*. [21] *Aragvadhadi Kashaya* having *Kandughna*, *Kushthaghn* and *Kaphahara* functions reduces specific features like *Ruja*, *Kandu*, *Vaivarnya*, *Strava* and *Rukshata*. [22] *Dushivisha* can be considered as accumulated toxins in the body at *Dhatu* and *Srotas* levels, provided by environmental and individual factors that may include *Pragnaparadha* and medications like steroids. [23] *Dushivishari agad a* contain *spittakaphaghna*, *vishaghna*, and *raktaprasadak* qualities and the *dravyas* there in are *kushthaghna*. It should therefore be used to treat skin conditions brought on by the modern, fast-paced lifestyle of today. [24]

CONCLUSION

The case study reveals that *Vicharchika* can be treated with *Panchakarma* and *Shamana* medicines. *Pathya sevana* plays an essential part in the management and lessens the chances of reoccurrence as no symptoms appear after 1 month at follow-up. *Vamana karma* aids the benefits of *Apunarbhavachikitsa* and repeated *Mrudu shodhana* creates clearance of





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Hruta dosha from *srotas*. *Shamana* acts as *Rasayana* mainly and does *poshana* of *dhatu*. In today's era maybe due to cumulative toxicity may create an imbalance in bodily humours and cause skin diseases which are difficult to treat; *Shodhana* treatment including *Panchakarma* followed by *Shamana* provides promising results. Further studies include repeated *mrudushodhanachikitsa* like *sadyovamana* with *shamana* as a treatment modality that can be examined in a large sample size to determine efficacy in such skin disorders.

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Table – 1 Gradation of symptoms/subjective parameters of Vicharchika^[4]

Symptoms	Gradation	Score
Kandu (Itching)	No itching	0
	Itching present rarely	1
	Itching disturbing the patient's attention	2
	Severe itching disturbing patient's sleep	3
Strava (Discharge)	No Strava	0
	Occasional Strava after itching	1
	Mild Strava after itching	2
	Profuse Strava making clothes wet	3
Pidaka (Papules)	Absent	0
	1-2 Pidaka in one affected part	1
	3-4 Pidaka in one affected part	2
	More than 4 Pidaka in one affected part	3
Shyavata / vaivarnyata (Discoloration)	Normal skin colour	0
	Brownish red discoloration	1
	Blackish red discoloration	2
	Blackish discoloration	3
Rookshata (Dryness)	No dryness	0
	Dryness with rough skin	1
	Dryness with scaling	2
	Dryness with cracking	3
Daha (Burning sensation)	Absence of Burning sensation in the affected part	0
	Rarely a burning sensation in the affected part	1
	Continues burning sensation in affected part	2
	Disturbing patients sleep	3

Table – 2 Gradation of symptoms/objective parameters of Vicharchika^[4]

Symptoms	Gradation	Score
Number of patches	No patch	0
	1-2 patches	1
	3-4 patches	2
	More than 5 patches	3





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Area of patches	In between 0-10 sq. cm	0
	In between 10-20 sq. cm	1
	More than 20 sq. cm	2

Table – 3 Vyavacchedakanidana(Differential Diagnosis)

Lakshana	Vicharchika	Vipadika	Pama
Dosha	Kaphapradhana ^[5]	Vata-kaphapradhana ^[5]	Pitta-kaphapradhana ^[5]
Vedana	SakanduPidika, Bahusrava, ^[5] Rukshata, Atiruja ^[6]	Tivravedana ^[5] Ruja ^[6] Manda kandu, ^[7]	KanduyuktaPidika, ^[5] Strava, Daha ^[6]
Varna	Shyava ^[5]	Rakta ^[7]	Shveta, Aruna, Shyava ^[5]
Samsthana	GatreAtikanduvat Raji ^[6]	Panipadasphutana ^[5] Saragapidika ^[7]	Anukavatpidika ^[6]
Sthana	Gatra (Panipada) ^[6]	Panipada ^[5]	Sphik, Pani, Kurpara ^[7]

Chikitsa:

Table – 4 Panchakarma treatment

Duration	Treatment	Medicine	Dosage
1 st day	Koshthashodhana	Trivrutaaavaleha, Triphalakashaya	30 gm, 80 ml
2 nd – 4 th days	Deepan-pachana Parisheka	Chitrakadivati, Vasaguduchyadikashaya Panchavalkala, Panchakola Kashaya	2-0-2 A.F., 15 ml B.D. B.F. 1.5 Lt.
5 th – 8 th days	Snehapana(Shodhanangamatra)	Mahatiktaghrita	1 st day – 30 ml 2 nd day – 60 ml 3 rd day – 90 ml 4 th day – 120 ml
9 th day	Abhyanga, Svedana	Murchhittaila	100 ml
10 th day	Vamana	Vamanayoga, Milk, Yashtimadhuphanta, Lavanodaka	Total – 12 gm (Madanaphalapippali – 6 gm, Yashtimadhu – 4 gm, Vacha – 1 gm, Saindhava – 1 gm, Madhu – Q.S.), 1 Lt., 3 Lt., 2 Lt.
11 th – 13 th days	Samsarjana krama	Peya, Vilepi, Yusha – Ahara kalpana	Q.S.
14 th – 20 th days	SthanikaParisheka	Panchavalkala, Panchakolakashaya	1.5 Lt.
21 st – 25 th days	Snehapana (Shamanangamatra)	Mahatiktaghrita	10 ml B.D. B.F.
26 th day	Sadyovamana	Yashtimadhuphanta	4 Lt.
27 th – 36 th days	SthanikaParisheka	Manjisthadi, Triphalakashaya	1.5 Lt.
37 th – 41 st days	Snehapana (Shamanangamatra)	Mahatiktaghrita	10 ml B.D. B.F.
42 nd day	Sadyovamana	Yashtimadhuphanta	4 Lt.





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Table – 5 Shamana treatment

Duration	Shamana medicine	Dose
17 days (14 th – 20 th days, 27 th – 36 th days)	ManjisthadiGhanavati	1-0-1 A.F.
	DushivishariAgad	1-0-1 A.F.
	KaishorGuggulu	2-0-2 A.F.
	Aragvadhadi Kashaya	15 ml BD B.F.

Table – 6 Observations on Vamana karma

Vamana criteria	Classical Vamana	Sadyo vamana	Sadyo vamana
Vaigiki	7 vega	4 vega	3 vega
Laingiki	Laghuta, Kapha-Pitta dosha nirharana	Deha laghava, Shiro laghava	Deha laghava, Shiro laghava
Maniki	6 Lt.	4 Lt.	4 Lt.
Antiki	Pittanta	Udara laghava	Udara laghava

Table – 7 Observations on Signs and Symptoms

Symptoms	Before treatment (Baseline)	After treatment (42 days)	Follow up (After 1 month)
Kandu (Itching)	3	1	1
Strava (Discharge)	2	0	0
Pidaka (Papules)	0	0	0
Shyavata/vaivamyata (Discoloration)	1	0	0
Rookshata (Dryness)	3	2	1
Daha (Burning sensation)	1	0	0
Number of patches	3	0	0
Area of patches	2	1	0



Fig 1: Before Treatment





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Fig 2: After Treatment



Fig 3: Follow up





Approaches for Parenteral Drug Delivery Systems: A Comprehensive Review

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ABSTRACT

The current study offers an overview of parenteral drug delivery systems, covering methods of administration, parenteral formulation, types of containers, and tests for evaluation. Parenteral preparations are sterile liquids devoid of pyrogens that include one or more active ingredients in single or multiple doses. They enter your body through an injection, an infusion, or an implant. Parenteral injections have the benefits of immediate systemic absorption and a rapid commencement of action. The stability of the active ingredient and finished formulation depends on the quality of the excipients, raw ingredients, and equipment maintenance. For drugs with a limited therapeutic index and active pharmaceutical components with low bioavailability, parenteral administration is the most widely used and effective method of delivery. This review article provides detailed information about parenteral dosage forms. A number of technological advancements in parenteral medication administration have led to the development of complex systems that enable drug targeting and the sustained or controlled release of parenteral medicines.

Keywords: Parenteral, Injection, Infusion, Implant, Therapeutic, Bioavailability





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INTRODUCTION

The word parenteral is obtained from "para" and "enteron" which signify to avoid the gut. It can be defined as preparations intended to administered through the skin or other external boundary tissue, rather than through the alimentary canal, so that the active substances can be administered directly into a blood vessel, organ, tissue, or lesion. Since parenteral injections are provided through the skin into blood stream, the body's most protective barriers, the products used in them must be "essentially" devoid of biologic contaminants. Most are injected directly into body tissues; they do not pass via liver and enter the bloodstream by avoiding first pass metabolism. This method offers several benefits for patients who need a quick start of action and are unable to take the medication orally, such as those who are asleep. Patients who are bedridden or in hospitals are entirely dependent on parenteral nourishment, which includes nutrients, electrolytes, and fluids. Parenterally delivered medications are typically quite strong requiring close monitoring of the patient's dosage. The quantity and use of parenteral products have increased globally since the development of biotechnology attained greater demand these days. Parenteral injections are either given readily via blood vessels for an immediate and well-controlled response or into the tissues beyond the circulation for a local or systemic effect. Parenteral dosage forms are a sterilized mixtures that can enter the body by injection, infusion, or implantation, among other methods. Parenteral fluids with different volumes are categorized as small and large injections.

- a. **Small volume parenterals** are injectables that are pyrogen-free and sterile. They are dispensed in ampoules for a single dosage and in vials for multiple doses, and prefilled syringes. Their sizes go up to 100 ml.
- b. **Large volume parenteral** products, often known as intravenous infusions or transfusion fluids, which has 100 ml or more that is meant to be given intravenously. These are intravenous infusions that are designed as single-dose injections. They consist mostly of water for injections and are sterilised aqueous solutions or emulsions. (5) Drug solubility, product stability, route of administration syringeability and manufacturability are few difficulties involved in developing a parenteral product. Modernization of pharmaceutical development and production will improve product quality. (6,7) Due to factors such the rising incidence of chronic illnesses, the rising need for biologics and biosimilars, and the continuous developments in drug delivery technology, the worldwide parenteral market is expected to continue growing. Businesses that can take advantage of technology advancements, adjust to changing market conditions, and meet unmet medical requirements stand a good chance of succeeding in this cutthroat environment. They cover a broad spectrum of goods, such as emulsions, suspensions, and solutions. Some parenteral formulations present in the market is given below in **Table 1**.

Characteristics of parenteral preparation

- They must be sterile.
- They need to be free of particulate matter, micro organisms and pyrogens.
- They should be isotonic with body fluids. They
- They should be sterile.

Advantages of parenteral preparation

- They have rapid onset of action.
- They are useful for unconscious patients.
- They can be used to give the medication in both conventional/ controlled manner depending on the excipients used.
- They have high first pass metabolites.
- They can be used for gastric irritating drugs.
- They are used to administer nutrients viz glucose and electrolytes.





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ROUTES OF ADMINISTRATION⁽⁹⁾

Various routes of administration of parenterals and their corresponding time to get onset of action are explained in **Table 2**.

TYPES OF PARENTERALS

Parenteral solutions can be used to get immediate or prolonged effect depending on the excipients used in the formulation and based on that they are classified as conventional and novel parenteral preparation.

Conventional parenteral preparations: ^(10,11)

Pharmaceutical preparations intended for delivery by routes other than the digestive tract, such as intravenous (IV), intramuscular (IM), or subcutaneous (SC) injection, are referred to as conventional parenteral formulations. In these formulations the drug will be suspended or dissolved in appropriate solvents or vehicles along with other buffers, stabilizers, preservatives, tonicity adjusters, buffers and other excipients if required. They may also include lyophilized powders for reconstitution, injectable solutions, suspensions, and emulsions. These formulations are essential for the prompt and efficient delivery of drugs, especially in emergency conditions.

Solutions : ⁽¹²⁾

An injectable product is presented in an isotonic aqueous solution with a pH close to blood and body tissues. Parenteral solutions include large volume parenterals (LVP), small volume parenterals (SVP), and irrigation solutions. Infusion fluids are larger volumes of aqueous solutions used for basic nutrition and electrolyte balance restoration. Formulation includes vehicles and added substances. There are three types of vehicles: aqueous vehicles, water miscible vehicles, and non-aqueous vehicles. Added substances in parenteral solutions may include antimicrobial agents, buffers, and chelating agents.

Suspensions : ^(13, 14)

Parenteral suspensions are a useful dosage form for administering insoluble or poorly soluble drugs. They are administered through subcutaneous and intramuscular routes and provide more prolonged release than solutions. Suspensions are better than solutions as they increase resistance to hydrolysis and oxidation. However, they face challenges like formulation difficulties, stabilization and dose nonuniformity. They will include suspending agents to get the stability of the product.

Emulsions : ^(15,16)

Emulsions are two-phase systems made by combining two immiscible liquids, one uniformly dispersed in the other, forming globules with diameters equal to or greater than those of large colloidal particles. Emulsions can be oil in water (o/w) or water in oil (w/o) and are prepared using oily drug, emulsifiers, preservatives, and antioxidants, solvents and other excipients if required. The main issue with emulsions is their thermodynamic instability due to the increase in surface free energy. Parenteral emulsions are administered through subcutaneous and intramuscular routes.

Novel parenteral preparations: ^(17,18)

Novel parenteral formulations for colloidal drug administration include nanoparticles, niosomes, liposomes, polymeric micelles, and in situ-formed systems.

Microspheres : ⁽¹⁹⁾

They should be formed of spherical particles smaller than 125 microns in size and can be delivered using a needle of 18 or 20 number needle. It is made up of solid, sphere-shaped particles dispersed in a biodegradable solution consisting of either solution or crystalline pharmaceutical particles. These particles have been used to deliver anti-cancer drugs and opioid antagonists. The matrix's degradation/dissolution governs the drug's release, which is constructed of bio-compatible and biodegradable polymers like Poly(lactic acid) & Poly(lactic-co glycolic acid).





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Nano emulsions : ^(1,20)

Nano emulsions are clear or translucent oil-in-water or water-in-oil mixtures with droplet diameters ranging from 100 to 500 nm. They are thermodynamically stable systems with a single phase, created using emulsifiers to stabilize two immiscible phases. The system is transparent and solubilized, free from common issues like creaming, flocculation, coalescence, and sedimentation. The methods used to create nano emulsions can be classified based on energy required, with high-powered procedures and minimal energy approaches. Oils used include castor beans, coconuts, soybeans, linseed, olives, peanuts, and PEG vegetable oil.

Nanosuspensions : ^(21,22)

Nanosuspensions are micron-sized colloidal dispersions containing solid active pharmaceutical ingredient particles in aqueous phase. They offer several advantages, including improved drug solubility and dissolution velocity, increased bioavailability of poorly soluble/hydrophobic drugs, and resistance to Ostwald ripening. Nanosuspensions are cost-efficient and technically easier to form, particularly for hydrophobic medicines. Current methods for nanosuspension formulation include precipitation, high-pressure homogenization (dissocubes), emulsion, and medium milling. Stabilizers and co-surfactants influence nanosuspensions' stability. Muthu et al. created a risperidone nanosuspension with Pluronic® F-68 and Pluronic® F-127 as a polymeric stabilizer, which increased a drug's therapeutic effectiveness and reduced injection frequency. Salem et al. developed a sustained release version of natural progesterone using stearic acid as a surface stabilizer, resulting in prolonged activity and reduced injection frequency. A method for creating a stable nanosuspension for vitamin B-12 administration has been granted a patent.

Niosomes : ^(23,24,25)

Niosomes are vesicular systems made of non-ionic surfactants, such as sorbitan esters and polysorbates. They are osmotically responsive and self-sustaining, allowing medication to be entrapped and delivered parenterally or topically. Niosomes are biodegradable, biocompatible, and non-immunogenic. They are widely used for parenteral delivery of various drug moieties. In a study, aerosolization was used to distribute hydrophobic cancer treatment using a combination of sorbitan esters and polysorbates, resulting in optimal encapsulation and nebulization efficiency.

Nanoparticles

A nanosuspension is a submicron-sized colloidal dispersion containing medication particles, produced using correct procedures and stabilized with surfactants. It is a prescription formulation for parenteral, pulmonary, oral, and topical administration. Nanosuspensions are developed using either top-down or bottom-up technology, resulting in crystal formation.

PREPARATION PROCEDURE FOR PARENTERALS

Parenteral preparation composition requires in-depth medication understanding and adjuvant use. Overuse of adjuvants in parenteral goods is something to be avoided since some of them might induce medication interactions. To create a stable preparation, the following ingredients are added.

Vehicle

It is used to dissolve or carry the drug and accidents. Types of vehicles used in the preparation of injections are given below.

Aqueous vehicle : ^(2,26)

Water is primarily employed as a transport since it is safe to introduce and well-satisfied by the body. Sterile water is the best solvent solution to use with parenterals. The monograph-recommended water quality, such as IP, USP, and BP. The quality was assessed by gravimetric analysis and TDS (total dissolved solid contents). The water-based vehicles in operation are:

- Water for injection.
- Water for injection free from CO₂
- Water for injection free from dissolved air.



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The parenteral formulation's most frequently utilized carrier. The water used for injection needs to be very chemically pure and devoid of pyrogen. BP claims that the only way to prepare the water for injection is through a distillation process. A glass still equipment can be used to prepare water for injection, preventing pyrogen contamination of the distillate. Acidic or alkaline gases like CO₂ and NH₃ are eliminated from the water during injection preparation to guarantee that the pH of the water is neutral. Pyrogens are byproducts of a microorganism's metabolism. Chemically speaking, pyrogens are lipid substances linked to a carrier molecule, which is often a polysaccharide but can also be a peptide. To ensure that the water used for parenteral and irrigating solutions is devoid of pyrogens, appropriate control must be exercised throughout preparation and water storage. Water may have pyrogen extracted using a straightforward distillation method.

Non aqueous vehicle : (27)

Non-aqueous carriers such as oils and alcohols are frequently utilized. Almond, cottonseed, and arachis oils are a few fixed oils that are employed as vehicles. Oily vehicles are typically utilized when a medicine has to have a depot effect, when the medication is soluble in oil but not soluble in water, or when both are needed. Features of the non-aqueous preparation medium utilized in parenteral administration. Non-irritating, non-toxic, and inert. When combined with additional substances, stable and compactable are employed. Must be viscous enough to be easily given and removed from the container. Propylene glycol, alcohol, and fixed oil are examples of non-aqueous solvents. 40% propylene glycol was used to make the stable parenteral preparation. 10% alcohol by volume and water, keeping the pH at 7.

Adjuvants / added agent : (28)

Material that has been mixed with active pharmaceutical ingredients (API) to improve stability or stop contamination. Parenteral preparation uses a variety of adjuvants, including stabilizers, chelating agents, buffering agents, and antifungal agents.

- **Antimicrobial agent** : These agents either eliminate microorganisms or stop their development. These agents are used in parenteral preparation to stop microorganisms from growing while being stored. A multidose bottle has an antimicrobial agent added due to the little likelihood of unintentional contamination during repeated usage. Benzalkonium chloride and phenylmercuric nitrate are the two most often utilized antibacterial agents.
- **Buffering agent** : These agents are used to modify the parenteral preparation's pH. the preparation's deterioration brought on by a pH shift. Add an appropriate buffer to maintain the pH of the preparation in order to avoid or stop this deterioration.
- **Antioxidants** : This substance keeps the preparation stable. The most often used antioxidant in aqueous parenteral nutrition is sulfite, bi sulfite, and metabisulfite salts of sulfur dioxide.
- **Tonicity agent** : It is crucial that the solution to be administered by intravenous means be isotonic, or as close to it as possible. Isotonic parenteral preparation is recommended for bodily fluids. Red blood cell haemolysis to ionic species across the red blood cell membrane can occur when the osmotic pressure varies. This is especially true when a non-isotonic solution is administered in quantities larger than 100 millilitres.
- **Solubilizers** : The solubilizers are used to preserve and stabilize the poor water soluble drug's aqueous solubility. similar to solubilizers like polysorbate and tweens.
- **Chelating agent** : Very few chelating agents, such as citric acid, tartaric acid, disodium edta, and various amino acids, are utilized in parenteral preparations. These agents help to complex heavy metals, which enhances the effectiveness of antioxidants and preservatives.

FILLING OF PARENTERALS (28,29,30)

Containers are composed of plastic or glass and are meant for parenteral products. Pharmacopoeia requires the following requirements for a container and closure that should be employed for parenteral preparation.

- No foreign substance should be present in the product.
- It must remain transparent for scrutiny in order to make the content apparent.
- There should be no negative consequences.



**Sharma et al.,****Glass**

The following three kinds of glass are used for container preparation:

- **Type 1 glass:** It is also known as borosilicate glass or resistant glass, and it is mostly used for chemical glassware, oven ware, and containers for alkali sensitive processing. Silica content is decreasing, although aluminium oxide is generally present. Boron oxide is created by combining silica with silicon dioxide.
- **Type 2 glass:** When wet sulphur dioxide is heated to a high temperature, soda lime silicate glass that has excellent hydrolytic resistance is formed. Glass containers are ideal for almost all acidic and intense liquid preparations.

Plastic

Organic polymers that are easily synthesised, can be moulded and extruded, and can be shaped and laminated. Specially designed for packing, but also used to make syringes, tubing devices, and saline solutions.

Advantages

- They are indestructible, because they are light in weight and their transportation cost is minimal.
- They are available in a variety of sizes and shapes.

Disadvantage

- The most typical issue is penetration.
- Since it is a container made of plastic, atmospheric gases, vapours, or fluids from the surrounding environment can enter.
- There are additional issues with oxidation and hydrolysis, as well as leaching.
- Various plastic materials are employed, including polyethylene, polypropylene, and polyvinylchloride.

Rubber Closures

Various types of rubber are utilised for this function, such as butyl rubber, nitrile rubber, silicon rubber, and others, due to their low absorption properties and lower cost than other rubbers. Butyl rubber is extensively used, although it decomposes at 130°C.

SEALING ^(28,31)

The filtered product is placed in final containers such as vials, ampoules, and transfusion bottles. Ampoules are used for single doses, whereas vials are used for several doses. Filling occurs in a laminar air flow.

Ampoules

They are meant for only one usage only; ampoules are opened by fracturing the glass at the scored line on the neck. The substance must be filtered before administration because glass fragments may get displaced during ampoule opening. Because of its unsuitability for multiple-dose administration, the requirement to filter solutions before use, and other safety concerns, ampoule use has decreased significantly.

Vials

These are either plastic or glass vials that are secured with a stopper made of rubber and sealed using an aluminium crimp.

Prefilled syringes

These are intended for easy administration and optimum convenience. When packed in prefilled syringes, emergency drugs (e.g., atropine, epinephrine) may be accessible for instant administration.





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Infusion solutions

They are classified into two types: small volume parenteral (SVP), which have a volume of 100 ml or less, as well as large volume parenteral (LVP), which have a volume of 100 ml or more. Infusion solutions are used to provide fluids or medications on an intermittent or continuous basis.

Seal the container either by fusion or with suitable closures :

Ampoules are manually sealed on a small scale by spinning the ampoules' necks in the flame of a Bunsen burner. Rubber closures are used to secure the vials and transfusion containers.

STERILIZATION METHODS

The absence of live microorganisms in pharmaceutical preparation is termed as sterilisation.

For sterilised parenteral preparation, many sterilisation methods are utilised.

- Sterilisation by moist heat
- Sterilisation by dry heat
- Filtration sterilisation
- Sterilisation with ionising radiation
- Sterilisation via gaseous means

Moist heat sterilization: ⁽³²⁾

- ✓ Moist heat sterilisation employs the application of steam at temperatures ranging from 121°C to 134°C.
- ✓ An autoclave is used to eliminate microorganisms and sterilise laboratory glassware, media, and reagents.
- ✓ This procedure is excellent for sterilising glassware, dressing, and closures, among other things.

Dry heat sterilization: ⁽³²⁾

- ✓ In comparison to wet heat sterilisation, dry heat sterilisation is conducted at a higher temperature and needs a longer period for the microbe to be exposed to this temperature.
- ✓ Maintaining temperature is 180°C, 170°C, 160°C for 30 minutes, 60 minutes, and 120 minutes.

Filtration sterilization: ⁽¹⁾

- ✓ This filtering process is used to sterilise thermolabile solutions by passing them through filters that eliminate microorganisms.
- ✓ This technique of sterilisation employs the total eradication of microorganisms within a certain size range from fluids.
- ✓ In general, membrane filters are effective in removing microorganisms.

Ionising radiation sterilisation: ⁽¹⁾

- ✓ There are two forms of radiation: electromagnetic radiation and particulate radiation.
- ✓ Electromagnetic radiation includes gamma radiation and X-rays.
- ✓ Particulate radiation includes beta and alpha radiation.

Gaseous sterilisation: ⁽³²⁾

- ✓ This approach may sterilise heat and moisture sensitive materials.

EVALUATION TESTS

In order to maintain quality control, the final parenteral product is submitted to the following test.

- Sterility test
- Clarity test
- Leakage test
- pH test
- Osmolarity test





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f. Pyrogen test

Sterility test : ^(33,34)

The sterility testing test is performed to determine the likely sterility of a certain batch. USP has given the necessary procedure instructions for sterility testing. USP's approved tests are the direct technique and the membrane filtering method. To avoid unintentional contamination of the product during the test, the test must be performed under aseptic conditions. The following procedures are followed for sterility testing:

Membrane filtration technique

This method basically involves filtration of Sample through membrane filters of porosity 0.22 micron and Diameter 47mm. The filtration is assisted under Vacuum, after filtration completion the membrane is placed in suitable media and incubated to check the growth. If growth is not observed sample is found to be sterile.

Direct inoculation method

The material is directly inoculated into two test tubes containing a culture. Because of the continual process of opening the container, transferring the sample, and mixing, this technique is conceptually simple but technically difficult. The parenteral preparation test sample is transferred into a test tube containing sterile culture media for anaerobic bacteria, aerobic bacteria, and fungi in an incubator. The test is incubated for a specific period and the turbidity in the sample is checked. If turbidity is present, it indicates microorganism growth and the sample fails the sterility test.

Clarity test: ⁽²⁶⁾

The product container is evaluated by an individual person in the presence of adequate illumination baffled against reflection in the eyes, and the product is seen against a black and white backdrop with the contents placed in motion with a swirling movement. If the particle is immobile, it is challenging to tell if it is moving, but air bubbles shouldn't be added since they are difficult to discern from dust particles. For detection of light particles, a black backdrop is utilised, whereas for detection of dark particles, a white background is required. If any foreign particle is visible in the parenteral preparation, the preparation is rejected.

Leakage test: ⁽³⁵⁾

The leakage test is carried out only on ampoules by sealing them with fusion so that leakage does not occur in them.

- ❖ Dye bath
- ❖ Vacuum chamber test

The leakage test is performed in the vacuum chamber test. After dipping the ampoules in a 1% solution of methylene blue in a vacuum chamber, the vacuum is applied, and the colour solution enters the ampoules when the suction is withdrawn. The colour solution has a faulty seal. If the colour solution enters the ampoule, it is reported as spilled and hence discarded. Rubbers are not utilised in this test due to their flexibility and unpredictability.

pH test

The best pH to choose is 7.4, which is the pH of blood. Excessive variation from this pH might lead to difficulties. Because blood is a great buffer, the recommended range for intravenous SVPs is 3.0 to 10.5. Other methods of administration of parenterals are routinely adjusted to a pH range of 4 to 9.

Osmolality test : ⁽⁵⁾

Osmolality is a practical way of determining the total contribution of the numerous solutes in the solution to the osmotic pressure that exists in the solution. According to the British Pharmacopoeia, water-based solutions for subcutaneous, intradermal, or intramuscular injection should be isotonic if feasible. Osmolality is measured in osmoles per kilogramme. Unless otherwise specified, osmolality is calculated by measuring the dip of the freezing point ΔT . The following relationship exists

$$\epsilon = \Delta T / 1.86 \times 1000 \text{ milli osmol/kg}$$





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Pyrogen test : ⁽²⁸⁾

The test used to determine whether or not pyrogen is present in a liquid parenteral solution. Pyrogens are created by microorganisms as a metabolic product; however the majority of pyrogenic chemicals are produced by gramme negative bacteria. They are thermostable polysaccharides. Because they are soluble in water and can flow through bacteria-proof filters, they are not impacted by bactericide. The exam is conducted in an air-conditioned environment. Dissolve the substance that has been tested in or diluted with pyrogen-free saline solution. The liquid should be tested at 38.5°C before injection. The amount of sample to be administered varies depending on the preparation under consideration and is specified in the specific monograph. The injection volume must be between 0.5ml and 10ml per kilogramme of body weight. A clinical thermometer detection probe is put into the rabbit's rectum to record the body temperature. Two normal rectal temperature recordings should be made to the test injection at half-hour intervals and the mean calculated, which is the starting temperature recorded for rabbit. The fluid is progressively injected into the ear vein in amounts ranging from 0.5 to 10 ml per kilogramme of body weight. Each rabbit's temperature is monitored every 30 minutes for three hours following injection. The difference between the rabbit's initial and maximum temperature measured is used to calculate its reaction. When this variation is negative, the reaction is zero. If an individual rabbit's reaction is less below 0.6°C, the preparation under consideration passes the test.

LABELLING & PACKING ⁽²⁸⁾

After the parenteral preparation is evaluated, the ampoules, vials, & transfusion bottles are appropriately marked and packed. The label should have the following information: the name of the preparation, the amount of the preparation, the manufacturer's licence number, the batch number, the date of manufacturing, and the date of expiration.

Limitations of parenteral preparations : ⁽²⁸⁾

- The injection site hurts when the medicine is administered. or local discomfort brought on by the insertion of the needle.
- They have high cost of production.
- They cannot be easily self-administered. The medication must only be delivered by trained individuals
- Individuals may experience an allergic response to a medication. These responses have a high fatality rate.
- During production, they had to maintain aseptic conditions or use the right aseptic procedure.

FUTURE PROSPECTS ⁽¹⁾

Breakthroughs in biotechnology and product development will end up resulting in more pharmaceutically active dosage forms that will be difficult to give via standard means of administration. Extended-release parenteral medications are difficult to administer, but they have emerged as a highly appealing strategy for managing the release of bioactive chemicals. In recent years, significant advances in the fabrication of injectable sustained release approaches have been made, as indicated by regulatory clearance and the market introduction of numerous new products. The aforementioned drug delivery methods offer a larger potential for a variety of applications, including cancer prevention medical care, radio imaging, genetic therapy, and AIDS therapy, among others. Although each administration strategy has advantages and disadvantages, innovative parenteral medication delivery technologies may increase drug bioavailability. When compared to traditional dose forms, these systems can also be used for acid and enzyme sensitive medications.

CONCLUSION

The drug delivery methods outlined here are utilized to control medicine distribution through parenteral injection. Parenteral routes of administration have matured into important technology platforms used by pharmaceutical companies in recent years. As a result, it is vital to investigate the parenteral medicine delivery system, as it allows for rapid treatment with the objective of rescuing a precious human life. The goal of intravenous controlled medicine



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administration is to maintain an optimal pharmacological response at a particular location while avoiding undesired interactions at other sites. It is done in two ways. The first method involves chemically modifying a parent molecule to make a derivative that is exclusively active where it is desired. The second technique employs carriers such as lipid membranes, spheres, nanoparticles, and macromolecules to transport the medicine to the target region. As a result, novel medication delivery systems must be developed in order to boost efficacy.

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Table 1 : List of some marketed parenteral formulation (8)

S.No.	Drug	Brand name	Activity	Manufacturer
1.	Aurothioglucose	Solganl®	Treating rheumatoid arthritis	Schering
2.	Betamethasone sodium phosphate And Betamethasone acetate	Celestor®	Treating Corticosteroid therapy	Schering
3.	Penicillin G Procaine	Bicillin®	Penicillin antibiotics	CR Wyeth
4.	Medroxyprogesterone acetate	DepoMedrol®	To treat pain and swelling that occurs with arthritis and other joint disorders	Upjohn
5.	Amino acid and dextrose	Aminosin	Dietary supplement for patients who are unable to get enough calorie and protein	Icu Medical Inc.
6.	Gentamicin	Genacyn LA	Antibiotic supplement	Zenley animal health
7.	Plerixafor	Adstem	Autologous stem cell transplant	ADLEY
8.	Daptomycin	Dapmicin	Treat severe infections of the skin, soft tissues, heart, and blood	Glenmark



**Sharma et al.,****Table 2 :Various routes of administration and time to get onset of action**

Administration site	Parenteral formulation	Time to get onset of action
Subcutaneous	Injected into the fatty layer under the skin	15-30 minutes
Intramuscular	Injected into the muscle	10-20 minutes
Intravenous	Injected into the vein. This allows for immediate adsorption. Intravenous includes IV push and IV infusion	30-60 seconds
Intradermal	Injected into the top layer of the skin at a slight angle	Variable (minutes to hours)
Intra-arterial	Injected into the joint	
Intracerebral	Injected into the dura matter (epidural space) of the spinal cord	
Intracardiac	Injected into the heart	
Intrathecal	Injected into the space surrounding the spinal cord	





Antibacterial Effects of Leaf Extracts of four Mangrove Plant Species on *Escherichia coli* and *Klebsiella pneumoniae*

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ABSTRACT

Microorganisms are responsible for several human diseases, throughout the world, which is a major reason for mortality and morbidity in immune-compromised patients. In this current investigation, the antibacterial activity of leaves of *Avicennia marina*, *Avicennia officinalis*, *Bruguiera cylindrica* and *Rhizophora apiculata* was evaluated against human pathogens such as *Escherichia coli* and *Klebsiella pneumoniae*. Ethanol extracts of mature leaves of these mangrove plants were prepared and tested for antibacterial activity using agar disc diffusion method. *Escherichia coli* was inhibited by leaf extracts of *A.marina*, *A.officinalis*, *B.cylindrica* and *R.apiculata*. Ethanol extract of *A.marina* and *A.officinalis* were able to inhibit the growth of *Klebsiella pneumoniae*. Charcoal treated leaf extracts of *Avicennia marina*, *Avicennia officinalis*, *Bruguiera cylindrica* and *Rhizophora apiculata* were able to inhibit the growth of both tested pathogenic bacteria more than that of untreated leaf extracts. The leaf extract of *Avicennia marina* exhibited highest antibacterial activity against *E.coli* and *K.pneumoniae* as compared to other extracts. The results suggested that these leaf extracts could be used as an alternative source for treatment of infections caused by these tested pathogenic bacteria.

Keywords: Mangrove, Anti-bacterial, *E.coli*, *Klebsiella pneumoniae*, *Avicennia marina*, *Avicennia officinalis*, *Bruguiera cylindrica*, *Rhizophora apiculata*





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INTRODUCTION

Mangroves are valuable ecological and economic resources, serving as important nursery grounds and breeding sites for birds, fish, crustaceans, shell-fish reptiles and mammals [1]. Mangroves and mangrove associates contain certain biologically active antiviral, cytotoxic, antioxidant, antibacterial and antifungal compounds, including steroids, triterpenes, saponins, flavonoids, alkaloids carbohydrate, reducing sugar, combined reducing sugar, glycosides, proteins, terpenoids and tannins [2][3][4]. Many of these compounds have pharmacological and therapeutic effects and they have been used in folk medicine to treat conditions such as elephantiasis, febrifuge, haematoma, hepatitis, ulcers, asthma, cancer, diabetes, rheumatism and fish poison, as they exhibit antioxidant, antibacterial, antifungal, anti-diabetic and anti-cancer activities [5]. The study was conducted at Ayiramthengu mangrove forest (lat. 9° 02' - 9° 16' N and long. 76° 20' - 76° 32' E), located in the Kollam district. The mangrove ecosystem is a part of Kayamkulam estuary (lat. 9° 07' - 9° 16' N and long. 76° 20' - 76° 28' E), a narrow stretch of tropical backwater on the west coast of Peninsular India[6]. The plant derived natural medicines, which are being used for centuries for the treatment of several human health issues, are relatively safer than the synthetic or artificial alternatives. The present study made an attempt to determine the antibacterial activity of leaf extracts from *Avicennia marina*, *Avicennia officinalis*, *Rhizophora apiculata* and *Bruguiera cylindrica* against two human pathogenic bacteria – *Escherichia coli* and *Klebsiella pneumoniae*.

MATERIALS AND METHODS

Collection of plant samples

Leaves of *Avicennia marina*, *Avicennia officinalis*, *Rhizophora apiculata* and *Bruguiera cylindrica* was collected from Ayiramthengu mangrove forest. The samples were washed thrice with sterile distilled water to remove epiphytes and other foreign particles and mopped using blotting sheets. The leaves were dried under shade for 20 days.

Preparation of leaf extracts

The leaves were chopped into small pieces and pulverized into fine powder using a pestle and mortar. 2.5 g of these powders were soaked in 10mL of ethanol (1:4 ratio). The containers were sealed and stored for a period of 3 days at room temperature. Each sample was then filtered through Whatman No. 1 filter paper and transferred into four beakers, which was then heated in a water bath at 40°C for 2 minutes for solvent evaporation. The extract was then centrifuged at 10,000 rpm for 2 minutes. The supernatant was maintained in eppendorf tubes at 4°C for later use.

Preparation of charcoal treated leaf extract

The leaf extracts of the four mangrove species, soaked in ethanol were filtered and transferred to four separate beakers. A small amount of charcoal was added. The mixture was then heated in a water bath at 40°C for 2 minutes and then centrifuged at 10,000 rpm for 2 minutes. The supernatant was then stored in eppendorf tubes at 4°C for later use [7].

Transfer of bacterial colonies to agar medium

Bacterial pathogens such as *Escherichia coli* and *Klebsiella pneumoniae* were obtained from Tropical Institute of Ecological Sciences (TIES), Kottayam. Bacterial colonies were transferred to nutrient agar medium through swab culture. The bacterial suspension of chosen bacterial pathogens was cultured over the surface of nutrient agar at 37± 2 °C in an incubator, free from contamination.

Antibacterial activity of leaf extracts

The ethanolic extract was impregnated on to a Whatmann filter paper No.1 disc (6 mm. diameter). Discs impregnated with the leaf extracts were placed on the solid agar medium by pressing slightly and incubated at 37±2°C for 18 - 24 h. After that, the zone of inhibition was measured and expressed in millimeter. The diameter of inhibition zone was considered as a measure of antibacterial activity.





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RESULTS AND DISCUSSIONS

In the present study, two human pathogenic bacteria were used to study the effects of mangrove plant leaf extracts of *Avicennia marina*, *Avicennia officinalis*, *Bruguiera cylindrica* and *Rhizophora apiculata* on their growth. Eight different leaf extracts were prepared and different extracts had different effects as listed in table 1 and table 2. As represented in Table 1, all leaf extracts were able to inhibit the growth of *E.coli*. The ethanolic leaf extracts of *A.marina* was more effective against *Escherichia coli* (14 mm), followed by *B.cylindrica* (9.67 mm) and *R.apiculata* (7.83). The leaf extract of *A.officinalis* showed least antibacterial activity against *E.coli* (7 mm). The maximum zone of inhibition for *Klebsiella pneumoniae* was recorded against *A.marina* (12.33 mm), followed by *A.officinalis* (8.5 mm). The ethanolic extract of *B.cylindrica* and *R.apiculata* was unable to inhibit the growth of *Klebsiella pneumoniae*. Controls did not exhibit any inhibitory effect on tested bacteria. These results agree with previous results [8][9]. *Avicennia marina* demonstrated significant inhibition against both bacteria. *Avicennia officinalis* showed moderate inhibition against both bacteria. *Bruguiera cylindrica* and *Rhizophora apiculata* exhibited inhibition against *E.coli* but not against *K.pneumoniae*. Charcoal treated plant extracts strongly inhibited the growth of pathogenic bacteria compared to untreated extracts. Table 2 shows the result of charcoal treated mangrove leaf extracts. The extract of *A.marina* (19.67 mm) showed more inhibition than *A.officinalis* (12.67 mm), *B.cylindrica* (13.33 mm) and *R.apiculata* (11.67 mm) against *E.coli*. In the case of *K.pneumoniae*, charcoal treated extract of *Avicennia marina* had an inhibition zone of 17 mm, followed by *A.officinalis* (12.33 mm), *B.cylindrica* (8.33 mm) and *R.apiculata* (9 mm). The result of antibacterial activity of charcoal untreated and treated mangrove plant leaves against *E.coli* and *K.pneumoniae* is illustrated in figure 3 and figure 4 respectively.

The activated charcoal may play a role in adsorbing impurities, concentrating active compounds, or influencing the release of bioactive substances, contributing to the observed improvements in antibacterial activity. These results suggest that charcoal treatment enhanced the antibacterial activity of the leaf extracts against *E.coli* bacteria. *Avicennia marina* exhibited an increase in the mean zone of inhibition from 14 mm (charcoal untreated) to 19.67 mm (charcoal treated). *Avicennia officinalis* showed an increase in the mean zone of inhibition from 7 mm to 12.67 mm with charcoal treatment. In case of *Bruguiera cylindrica*, the mean zone of inhibition increased from 9.67 mm to 13.33 mm, and for *Rhizophora apiculata*, mean zone of inhibition increased from 7.83 mm to 11.67 mm. Inhibition of *Klebsiella pneumoniae* also showed significant increases with the charcoal-treated extracts. *Avicennia marina* exhibited an increase from 12.33 mm to 17 mm, while *A.officinalis* showed an increase from 8.5 mm to 12.33 mm. *B.cylindrica* displayed an increase in the zone of inhibition from 0 mm to 8.33 mm, and *R.apiculata* exhibited growth inhibition increase from 0 mm to 9 mm. The current study leads to the result that, mangrove plant species of *Avicennia marina*, *Avicennia officinalis*, *Bruguiera cylindrica* and *Rhizophora apiculata* can be considered to produce new medicines for certain bacterial infections.

CONCLUSION

In conclusion, the evaluation of antibacterial activity in mangrove plant extracts against human pathogenic bacteria holds promise for both scientific understanding and practical applications. The potential integration of mangrove plant extracts into pharmaceuticals or topical treatments could address the increasing challenges posed by resistant bacterial strains. The specific strains tested and the corresponding susceptibility patterns provide valuable insights into the potential therapeutic applications of mangrove plant extracts. To contextualize the findings, a comparative analysis with existing antibacterial agents or synthetic drugs could be beneficial. This would help in assessing the relative efficacy of mangrove plant extracts and their potential as alternative or complementary treatments in the face of antibiotic resistance. The study opens avenues for future research, including the isolation, purification and identification of specific bioactive compounds responsible for antimicrobial activity. Further investigations might focus on exploring synergistic effects with conventional antibiotics, or conducting in vivo studies to assess the safety and efficacy of these plant extracts.





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Table 1: Mean Zone of Inhibition of Untreated Leaf Extracts

Bacteria	Mean zone of inhibition in diameter (mm)				
	Control	<i>Avicennia marina</i>	<i>Avicenniaofficinalis</i>	<i>Bruguieracylindrica</i>	<i>Rhizophoraapiculata</i>
<i>Escherichia coli</i>	0	14	7	9.67	7.83
<i>Klebsiella pneumoniae</i>	0	12.33	8.5	0	0

The mean zone of inhibition of untreated ethanolic mangrove leaf extracts on *E.coli* and *Klebsiella*. '0' indicates no zone of inhibition.

Table 2: Mean Zone of Inhibition of Charcoal Treated Leaf Extracts

Bacteria	Mean zone of inhibition in diameter (mm)				
	Control	<i>Avicennia marina</i>	<i>Avicenniaofficinalis</i>	<i>Bruguieracylindrica</i>	<i>Rhizophoraapiculate</i>
<i>Escherichia coli</i>	0	19.67	12.67	13.33	11.67
<i>Klebsiella pneumoniae</i>	0	17	12.33	8.33	9

Mean zone of inhibition of charcoal treated ethanolic mangrove leaf extracts on *E.coli* and *K.pneumoniae*. '0' indicates no zone of inhibition.





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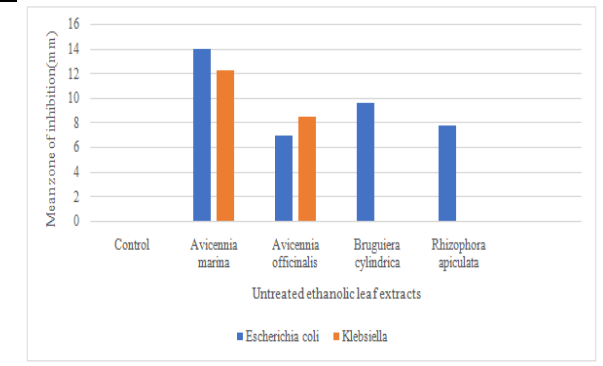


Figure 1: Mean zone of inhibition of *E.coli* and *K.pneumoniae* by untreated ethanolic leaf extracts of *Avicennia marina*, *Avicenniaofficinalis*, *Bruguiera cylindrica* and *Rhizophoraapiculata*.

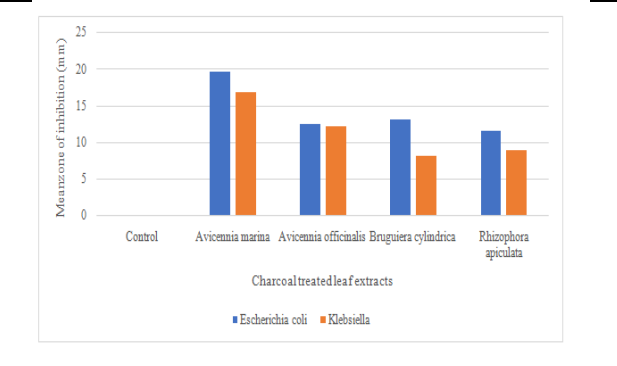


Figure 2: Mean zone of inhibition of *E.coli* and *K.pneumoniae* by charcoal treated ethanolic leaf extracts of *Avicennia marina*, *Avicenniaofficinalis*, *Bruguiera cylindrica* and *Rhizophoraapiculata*.

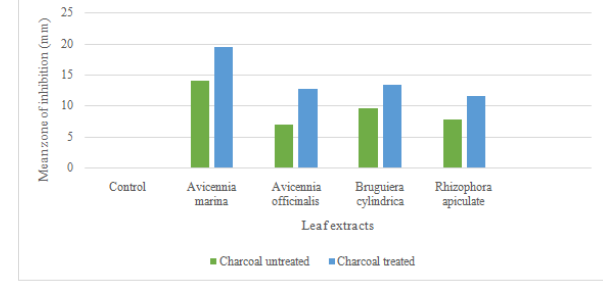


Figure 3: Comparison of mean zone of inhibition of *Escherichia coli* using charcoal treated and untreated leaf extracts of *Avicennia marina*, *Avicenniaofficinalis*, *Bruguiera cylindrica* and *Rhizophoraapiculata*. UT- Charcoal untreated, T-Charcoal treated

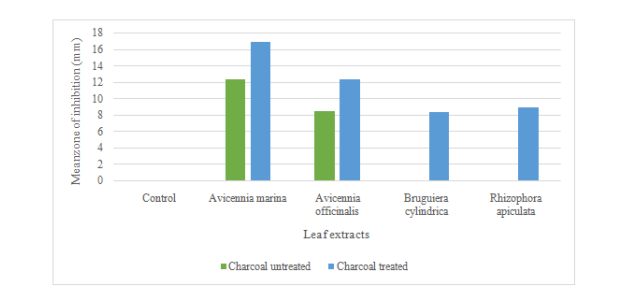


Figure 4: Comparison of mean zone of inhibition of *Klebsiella pneumoniae* using charcoal treated and untreated leaf extracts of *Avicennia marina*, *Avicenniaofficinalis*, *Bruguiera cylindrica* and *Rhizophoraapiculata*. UT- Charcoal untreated, T-Charcoal treated

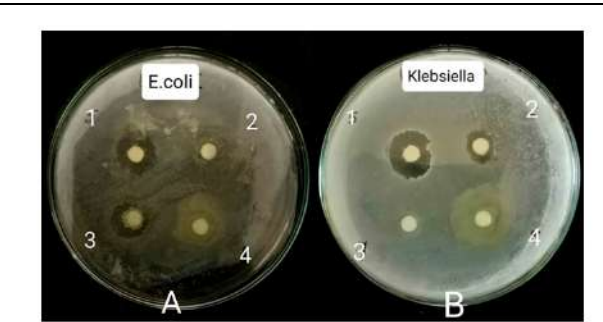


Figure 5: The inhibition zone of untreated ethanolic extracts of *Avicennia marina* (1), *Avicennia officinalis* (2), *Bruguiera cylindrica* (3) and *Rhizophora apiculata* (4) against *Escherichia coli* (A), *Klebsiellapneumoniae*(B) at concentration of 25µL

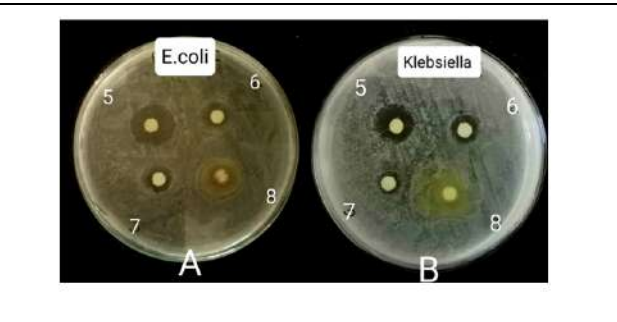


Figure 6: The inhibition zone of charcoal treated ethanolic extracts of *Avicennia marina* (5), *Avicennia officinalis* (6), *Bruguiera cylindrica* (7) and *Rhizophora apiculata* (8) against *Escherichia coli* (A), *Klebsiellapneumoniae*(B) at concentration of 25µL





Enzymic and Non-Enzymic Antioxidant Activities of *Momordica charantia* and *Trigonella foenum graecum* Seed Extracts in Diabetes Induced Rats

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ABSTRACT

This present study was performed to evaluate the enzymic and non-enzymic antioxidant activities of *Momordica charantia* and *Trigonella foenumgraecum* seed extracts in diabetes induced rats. Diabetes Mellitus was induced by a single intraperitoneal injection of STZ-NIC and rats with blood glucose concentration more than 250mg/dl were used for the study. The ethyl acetate seed extracts of the plant samples were administered at doses of 200, 400 mg/kg b.w and glibenclamide for 21 days and the activities of enzymic antioxidants superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) and non-enzymic antioxidants namely vitamin C, vitamin E and reduced glutathione (GSH) and lipid peroxidation were evaluated. There was a significant improvement in the activities and the levels of enzymic and non-enzymic antioxidants catalase, glutathione peroxidase, superoxide dismutase, vitamins C, E and reduced glutathione (GSH) and lipid peroxidation on treatment with 400mg/kg b.w of the plant extracts and glibenclamide. This study demonstrates the antioxidant effect of the *Momordica charantia* and *Trigonella foenumgraecum* seed extracts that might help in control and prevention of diabetes mellitus.

Keywords: Diabetes, Enzymic antioxidants, Non-enzymic antioxidants, *Momordica charantia*, *Trigonella foenumgraecum*.



**Renuka****INTRODUCTION**

Diabetes mellitus (DM) is a complicated, and non-contagious endocrine ailment that has posed clinical challenges globally, often linked with threats related to complicated metabolic development in patients. Elevated blood glucose, lipids, and oxidative stress are its hallmarks. These factors lead to chronic problems that affect several organs in the body, primarily the eyes, nerves, kidneys and blood vessels. World Health Organization (WHO) has reported that DM is an outbreak prone to high malaise and death [1]. During hyperglycemia, production of reactive oxygen species and reactive nitrogen species increases. This results in decrease in the activity of antioxidant enzymes, induces oxidative stress in the body [2]. Reactive oxygen species (ROS) level elevation in Diabetes may be due to perturbations in antioxidant defense system. The variation in the levels of antioxidant enzymes makes the tissues susceptible to oxidative stress leading to the development of diabetic complications[3]. Antioxidants are biochemicals that can neutralize the potentially damaging action of free radicals such as unstable molecules as peroxy radical, hydroxyl radical and singlet oxygen and peroxy nitrate radicals. Antioxidants either completely stop or significantly reduce the damaging effects of free radicals on cells. Thus, research on antioxidants and free radicals is crucial to understanding the connections between diseases including cancer, neurological disorders, diabetes mellitus, and cardiac arrest[4]. The fact that medicinal plants are widely accessible and have less adverse effects when used to treat diabetes is one of their many benefits. Approximately 800 plants have been reported to have potential antidiabetic properties[5]. Antioxidants are present in all parts of plants like wood, bark, stems, pods, leaves, fruit, roots, flowers, pollen and seeds. The fact that several antioxidant chemicals have been identified in plant tissue is explained by the existence of such oxidative processes in plants. Plants, particularly those with high concentrations of potent antioxidant chemicals, are crucial for the prevention and treatment of oxidative stress-related diseases including diabetes mellitus [6]. *Momordica charantia* commonly known as bitter melon grows in tropical and subtropical areas, and is used as a food and medicine. It yields prickly fruit and lovely flowers. While bitter melon seeds, leaves, and vines have all been utilized for medicinal purposes, the fruit of the plant is the most widely used and safest part [7]. *Momordica charantia* seed extracts showed potent free radical scavenging activity, alpha- amylase inhibition and the mechanism were found to be noncompetitive inhibition[8]. *Trigonella foenum graecum* (Fenugreek) is a leguminous bean and which belongs to the family Fabaceae. There are numerous medical uses for the green leaves and seeds of *Trigonella foenum graecum*, which are consumed. In 2012–2013, India produced 113 thousand metric tonnes of fenugreek overall. It is widely used as traditional medicine in China and as a component of ayurvedic medicine in India. Fenugreek is consumed in various parts of the world in different forms and has been regarded as a treatment for many ailments known to man [9]. Hence the present study was aimed to evaluate the *in vivo* antioxidant potential of *Momordica charantia* and *Trigonella foenum graecum* seed extracts in Streptozotocin– Nicotinamide administered diabetes induced rats.

MATERIALS AND METHODS**Plant Collection, Identification and Preparation of Extract**

Momordica charantia seeds (MCS) and *Trigonella foenum graecum* seeds (TGS) were dried, finely powdered, and stored in airtight containers at room temperature for further use. Five grams of *Momordica charantia* and *Trigonella foenum graecum* seed powder was extracted with 50 ml of ethyl acetate for 48 hours filtered and collected the extract. The solvent extract was evaporated in water bath shaker to get dry extract and used for further analysis.

Experimental Animals

Adult male albino Wistar rats (6 weeks), weighing 150 to 200 g were used for the present antidiabetic study. The animals were housed in clean polypropylene cages and maintained in a well-ventilated temperature-controlled animal house with a constant 12-hour light/dark schedule. The rats were given a normal pelleted food to eat, and they had unlimited access to clean drinking water. Following the guidelines for the appropriate care and use of laboratory animals, and with approval from the Ethical Committee Clearance No. 53 IAE1012/c/17/CPCSEA-2013, all animal treatments were carried out.





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Acute toxicity studies

Using three healthy rats (n= 3), an acute oral toxicity study of *Momordica charantia* seeds (MCS) and *Trigonella foenum graecum* seeds (TGS) was conducted in accordance with guidelines established by the Organisation for Economic Co-operation and Development (OECD). The plant extract was evaluated for the pharmacological potential in normal rats weighing 150 to 200 g. The animals were given 200 mg/kg of MCS and 2000 mg/kg of TGS initially, then 500, 1000, 1500, and 2000 mg/kg b.w., and their toxicity was assessed. For a full day, the animals were watched for signs of death. Further studies were conducted using 1/5th and 1/10th of the highest dose (2000 mg/kg b.w.) as there was no mortality observed in the acute toxicity studies.

Induction of Diabetes Mellitus

The animals were kept overnight fasting and the initial fasting blood glucose was checked from tip of rat tail vein. Regular saline was used to dissolve nicotinamide, while citrate buffer (pH 4.5) was used to dissolve streptozotocin. A single intraperitoneal injection of 60 mg/kg streptozotocin was given to overnight fasted rats 15 minutes after an i.p. injection of 120 mg/kg nicotinamide. This caused the rats to develop diabetes mellitus. After 72 hours, the higher blood glucose levels were used to confirm diabetes. The animals with blood glucose concentration more than 250mg/dl were used for further study. The vehicle (saline), standard drug glibenclamide and plant extracts were administered to the respective group animals for 21 days. Throughout the study period glibenclamide and plant extracts were freshly dispersed in normal saline and distilled water before the administration.

Sample collection

At the end of the experimental period rats were fasted overnight and anaesthetized with diethyl ether (100ml/kg), blood samples were collected through retro-orbital sinus puncture with or without EDTA container for the estimation of selected biochemical and haematological parameters. The liver of the experimental rats was removed and a portion of each was stored at minus 40°C for performing the assays involving enzymic and non-enzymic antioxidants.

Determination of Enzymic antioxidants

The activities of enzymic antioxidants namely superoxide dismutase, catalase and glutathione peroxidase were determined in the liver of the control and experimental rats to assess the protection rendered by MCS, TGS and glibenclamide [10,11,12].

Determination of Non enzymic antioxidants

The activities of non-enzymic antioxidants vitamin C, vitamin E and reduced glutathione were determined in the liver of the control and experimental rats to assess the protection rendered by MCS, TGS and glibenclamide [13,14,15].

Determination of lipid peroxidation

Increased production of lipid peroxides such as malondialdehyde (MDA) and free radicals may be caused by hyperglycemia linked to hyperlipidemia [16]. Hence lipid peroxidation in experimental rats was estimated [17].

Statistical Analysis

After statistical analysis of the data, Dunnett's multiple comparison test and One-way Analysis of Variance (ANOVA) were used to determine statistical significance. A statistically significant 'p' value was defined as less than 0.05.

RESULTS AND DISCUSSIONS

An imbalance of oxidant and antioxidant defence systems result in alterations in the activity of antioxidant enzymes such as superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx). In the present study, the





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activity of superoxide dismutase, catalase and glutathione peroxidase in normal and Diabetes induced rats were evaluated. The results of antioxidant activity of enzymes on control and experimental rats are depicted in Figures 1 a, 1b and 1c. There was a significant decrease ($p < 0.05$) in the activity of enzymic antioxidants namely superoxide dismutase, catalase and glutathione peroxidase in the liver of diabetic control rats. In diabetic rats treated with glibenclamide and plant extracts, there was a significant improvement ($p < 0.05$) in the activity of these enzymes. The activity of these enzymes in rats treated with highest dose of 400mg/kg b.w of MCS was comparable to the activity of enzymes in glibenclamide treated rats. A decrease in the antioxidative enzyme activities of SOD, CAT, and GPx is referred to as oxidative stress. Cell stress can be decreased in part by the antioxidant enzymes SOD and CAT. While CAT reduces hydrogen peroxides and shields higher tissues from extremely reactive hydroxyl radicals, SOD scavenges the superoxide radical by converting it to hydrogen peroxide and molecular oxygen [18].

The decreased activities of CAT and SOD may be response for increased production of H_2O_2 and O_2 by the auto-oxidation of glucose. Because these enzymes accelerate the dismutation of oxygen radicals and remove organic peroxides and hydroperoxides produced by unintentional exposure to STZ, they are crucial for maintaining physiological levels of oxygen and hydrogen peroxide. [19]. Treatment with MCS and TGS seemed to increase the activity of these enzymes and might help to control free radicals when compared to Glutathione peroxidase enzyme is relatively stable, but it has been reported that is disabled in severe oxidative stress conditions. It is noteworthy that diabetic rats treated with *Citrullus lanatus* (watermelon) displayed an increase in Gpx status activity that was nearly identical to the control level. This suggests that the juice may have a moderating effect on the altered antioxidant status of the diabetic rats [20]. The activities of antioxidant enzymes SOD and CAT were significantly increased after the treatment of ethyl acetate fraction of ethanol extract of *Stereospermumsuaveolens* in STZ-induced diabetic rats indicating the free radical scavenging activity and their protective effect against diabetic kidney cellular damage [21]. Treatment with root extracts of *Premnacorymbosa* (Rottl.) increased the activity of antioxidant enzymes SOD, CAT and GPx when compared to diabetic rats. The effect produced by plant extract was comparable with that of standard drug glibenclamide [22].

Non enzymic antioxidants

The changes in the levels of non-enzymic antioxidants namely vitamin C, vitamin E and reduced glutathione (GSH) are important in cellular system in curtailing reactive oxygen species. The levels of these non – enzymic antioxidants in control, diabetic and treated rats were assessed and the results are depicted in Figures 2 a, 2 b and 2 c. There was a significant reduction ($p < 0.05$) in the nonenzymatic antioxidants namely vitamins C, E and reduced glutathione (GSH) in diabetic rats when compared to control rats. The levels of these antioxidants were significantly increased ($p < 0.05$) in rats by treating with glibenclamide, MCS and TGS ethyl acetate extracts. The levels of vitamin C, E and reduced glutathione were found to be increased significantly ($p < 0.05$) on treatment with 400mg /kg b.w. Vitamin C is an effective antioxidant in various biological systems [23]. Vitamin C plays a central role in the antioxidant protective system, protecting all lipids undergoing oxidation and diminishing the number of apoptotic cells [24]. Vitamin E acts as a non-enzymatic antioxidant and reduces chain reactions of lipid peroxidation [25]. Vitamin E shields cell structures from damage by reducing lipid hydroperoxides produced during the peroxidation process.

The decreased level of vitamin E found in the liver of diabetic rats as compared with control rats could be due to increased oxidative stress, which accompanies the decrease in the level of antioxidant and might be related to the cause of Diabetes Mellitus [26]. Enhanced level of vitamin E or tocopherols in plant extract treated groups is based on their ability to donate phenolic hydrogens to lipid radicals. Vitamin E protects poly unsaturated fatty acids from being oxidized [27]. Decreased levels of nonenzymatic antioxidant vitamin C and E in diabetic rats, when compared to those of control rats. Treatment with root extracts of *Premna corymbosa* (Rottl) resulted in a considerable rise in these antioxidants in the liver, kidney, brain, heart, and pancreas of diabetic rats [28]. GSH has a multifaceted role in anti-oxidant defence. It is a co-substrate for glutathione peroxidase's peroxide detoxification process and a direct scavenger of free radicals [29]. Hyperglycemia is found to be an indirect cause of GSH depletion. As GSH is an important antioxidant molecule, its depletion leads to an increase of oxidative stress [30]. After taking *Passiflora ligularis*'s aqueous fruit extract orally for 30 days, all non-enzymatic antioxidant values significantly increased and





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eventually approached normal levels. This can reduce the oxidative stress leading to less degradation of GSH due to less production of ROS in diabetic stage [31]. In the present study, there was an increased level ($p < 0.05$) of reduced glutathione in MCS and TGS treated groups which imply that the plant extracts might have an enhanced amount of GSH activity which plays a role in coordinating the body's antioxidant defense processes. Reduced glutathione, synthesized mainly in the liver is an important non- enzymic antioxidant in the antioxidant defense system.

Lipid peroxidation

The status of lipid peroxidation of control and experimental rats were studied and the results are depicted in Figure 3. Lipid peroxidation was increased significantly ($p < 0.05$) in diabetic rats as compared to that of control rats. The rats treated with glibenclamide, MCS and TGS showed significant reduction ($p < 0.05$) in lipid peroxidation. The diabetic rats treated with highest dose of 400mg/kg b.w showed significant improvement ($p < 0.05$) in antioxidant activity and the reduction in malondialdehyde production was comparable to glibenclamide treated rats. Lipid peroxidation is an autocatalytic free radical process formed by oxidative damage of cells. ROS produced in tissues results in lipid peroxidation and subsequently enhances the levels of malondialdehyde which is the major end product and index of lipid peroxidation [32]. Polyunsaturated lipids oxidatively deteriorate due to a process called lipid peroxidation, which is mediated by free radicals. The primary cause of the rise in oxygen free radicals in diabetes may be elevated blood glucose levels, which produce free radicals by auto-oxidation[33]. *Coleus vettiveroides* extract possess potent antioxidant and lipid peroxidation activities and can be employed in protecting tissue from the oxidative stress, which might be responsible for its hypoglycemic property [34]. In the current investigation, elevated lipid peroxidation in diabetic rats generated by STZ may be attributed to an upsurge in free radical production by STZ. Lipid peroxidation inhibition appears to be closely related to MCS and TGS extracts' capacity to squelch hydroxyl radicals. After oral administration of the plant extracts for 21 days the elevated values restored back to near normal level. Lipid peroxidation significantly decreased in the treated groups, indicating that it plays a protective role against lipid peroxidation.

CONCLUSION

In the present study *in vivo* antioxidant activities of *Momordica charantia* and *Trigonella foenumgraecum* seed extracts in streptozotocin– nicotinamide administered diabetes induced rats showed a significant improvement in the activities and the levels of enzymic and non-enzymic antioxidants catalase, glutathione peroxidase, superoxide dismutase, vitamins C, E and reduced glutathione (GSH) on treatment with plant extracts. The rats treated with MCS and TGS also showed significant reduction in lipid peroxidation. The various antioxidant activities exhibited by *Momordica charantia* and *Trigonella foenumgraecum* may be attributed to their effectiveness as good scavengers of free radicals. Hence, these might be useful in the control of hyperglycaemia and due to its potent antioxidant properties may help in prevention of complications in diabetes.

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CONFLICTS OF INTEREST

The author declares that there are no conflicts of interest





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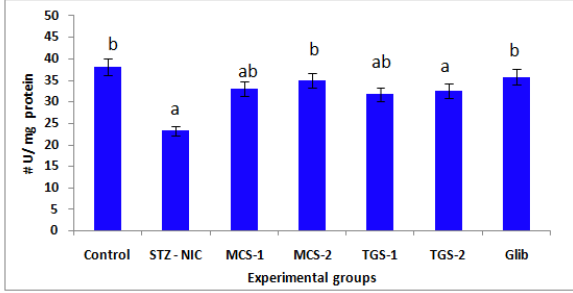
<p>Values are mean± SEM (n= 6) @ 1 Unit: Amount of enzyme that causes 50% reduction in NBT oxidation a-p <0.05 compared with control group b-p <0.05 compared with STZ –NIC group c-p <0.05 compared with Glib (200µg/kg b.w) treated group</p>	<p>Values are mean± SEM (n= 6) *1 Unit: Amount of enzyme required to decrease the absorbance at 240nm by 0.05 units a-p <0.05 compared with control group b-p <0.05 compared with STZ –NIC group c-p <0.05 compared with Glib (200µg/kg b.w) treated group</p>



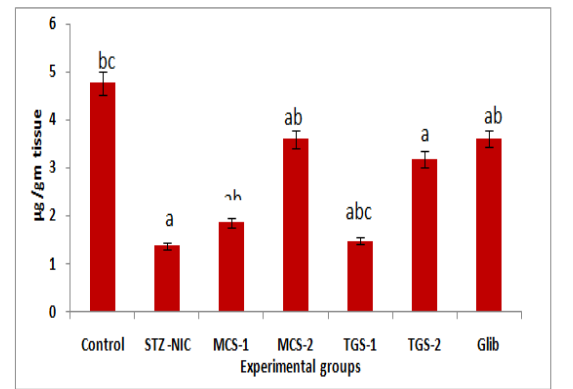


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(One way ANOVA followed by Dunnett's multiple Comparison test)
 MCS -1: 200mg/kg b.w, MCS-2:400mg/kg b.w, TGS -1: 200mg/kg b.w, TGS 2:400mg/kg b.w.
Figure 1a: Activity of hepatic superoxide dismutase in the experimental rats

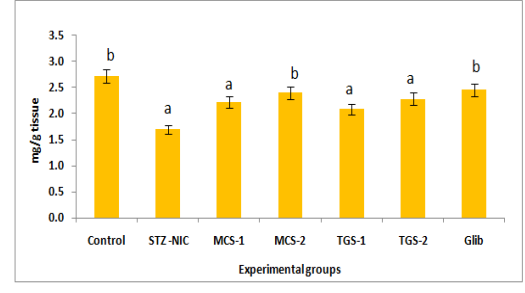


Values are mean± SEM (n= 6)
 # 1 Unit: μ moles of GSH consumed/minute//mg liver protein.
 a-p <0.05 compared with control group
 b-p <0.05 compared with STZ –NIC group
 c-p <0.05 compared with Glib (200μg/kg b.w) treated group
 (One way ANOVA followed by Dunnett's multiple Comparison test)
 MCS -1: 200mg/kg b.w, MCS-2:400mg/kg b.w, TGS -1: 200mg/kg b.w, TGS -2:400mg/kg b.w
Fig 1c: Activity of hepatic glutathione peroxidase in the experimental rats



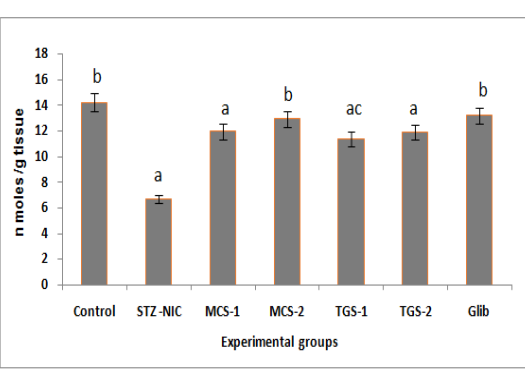
Values are mean± SEM (n= 6)
 a-p <0.05 compared with control group
 b-p <0.05 compared with STZ –NIC group
 c-p <0.05 compared with Glib (200μg/kg) treated group
 (One way ANOVA followed by Dunnett's multiple Comparison test)
 MCS -1: 200mg/kg b.w, MCS-2:400mg/kg b.w, TGS -1: 200mg/kg b.w, TGS -2:400mg/kg b.w.

(One way ANOVA followed by Dunnett's multiple Comparison test)
 MCS -1: 200mg/kg b.w, MCS-2:400mg/kg b.w, TGS -1: 200mg/kg b.w, TGS -2:400mg/kg b.w.
Figure 1b: Activity of hepatic catalase in the experimental rats



Values are mean± SEM (n= 6)
 a-p <0.05 compared with control group
 b-p <0.05 compared with STZ –NIC group
 c-p <0.05 compared with Glib (200μg/kg b.w) treated group
 (One way ANOVA followed by Dunnett's multiple Comparison test)
 MCS -1:200mg/kg b.w, MCS-2:400mg/kg b.w, TGS -1: 200mg/kg b.w, TGS -2:400mg/kg b.w.

Figure 2a: Levels of hepatic vitamin C in the experimental rats

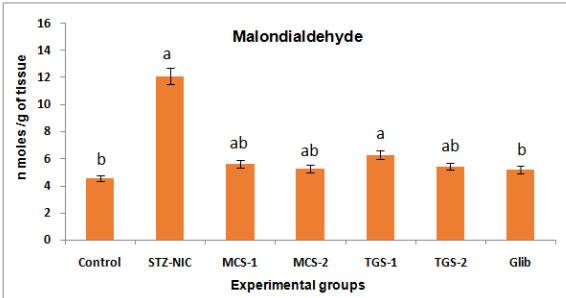


Values are mean± SEM (n= 6)
 a-p <0.05 compared with control group
 b-p <0.05 compared with STZ –NIC group
 c-p <0.05 compared with Glib (200μg/kg b.w) treated group
 (One way ANOVA followed by Dunnett's multiple Comparison test)
 MCS -1: 200mg/kg b.w, MCS-2:400mg/kg b.w, TGS -1:





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<p>Figure 2b : Levels of hepatic vitamin E in the experimental rats</p>	<p>200mg/kg b.w, TGS 2:400mg/kg b.w. Figure 2 c :Levels of hepatic reduced glutathione in the experimental rats</p>																								
 <table border="1" style="margin: 10px auto; border-collapse: collapse;"> <caption>Estimated data for Figure 3: Lipid peroxidation in the liver of experimental rats</caption> <thead> <tr> <th>Experimental group</th> <th>Malondialdehyde (n moles/g of tissue)</th> <th>Significance</th> </tr> </thead> <tbody> <tr> <td>Control</td> <td>~4.5</td> <td>b</td> </tr> <tr> <td>STZ-NIC</td> <td>~12.0</td> <td>a</td> </tr> <tr> <td>MCS-1</td> <td>~5.5</td> <td>ab</td> </tr> <tr> <td>MCS-2</td> <td>~5.0</td> <td>ab</td> </tr> <tr> <td>TGS-1</td> <td>~6.0</td> <td>a</td> </tr> <tr> <td>TGS-2</td> <td>~5.5</td> <td>ab</td> </tr> <tr> <td>Glib</td> <td>~5.0</td> <td>b</td> </tr> </tbody> </table>		Experimental group	Malondialdehyde (n moles/g of tissue)	Significance	Control	~4.5	b	STZ-NIC	~12.0	a	MCS-1	~5.5	ab	MCS-2	~5.0	ab	TGS-1	~6.0	a	TGS-2	~5.5	ab	Glib	~5.0	b
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Ensuring Sustainability: Embedding Environmental Education in Teacher Training

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ABSTRACT

This paper addresses the crucial role of teacher education in ensuring a sustainable future. It argues that by embedding Environmental Education (EE) within teacher training programs, educators can become powerful agents for fostering environmental awareness and action in future generations. The article explores the theoretical framework of Education for Sustainable Development (ESD) and its practical application as EE. It outlines the core knowledge base for effective EE, encompassing ecological literacy, environmental issue analysis, and pedagogical approaches to integrate sustainability across the curriculum. Furthermore, the paper examines practical strategies for embedding EE in teacher training programs, focusing on curriculum development, innovative teaching methods (e.g., project-based learning, field studies), and fostering collaboration between teacher educators and environmental experts. By equipping teachers with the necessary tools and fostering their own environmental stewardship, teacher training programs can become a critical catalyst for building a generation committed to a sustainable future.

Keywords: Education, Environment, Teacher Training, Sustainable Development, etc.





Neeraj Yadav and Lohans Kumar Kalyani

INTRODUCTION

In the field of environmental education, there is a notable lack of emphasis in both pre-service and in-service teacher education programs, underscoring the connection between environmental education and teacher preparation. Numerous national and international institutions provide extensive teacher preparation programs that combine standard pedagogical instruction with environmental education. The purpose of this paper is to emphasize how important it is for teacher educators to use awareness-building techniques. The goal of environmental education is to raise awareness of environmental issues among people all over the world and to make them deeply care about them. Its main objective is to provide people with the information, abilities, attitudes, drive, and dedication needed to deal with current environmental issues in a cooperative manner while actively averting the emergence of future ones.

Aims and Objectives

1. Environmental education has many goals, including raising public awareness of environmental issues, encouraging the investigation of possible outcomes, and laying the foundation for fully informed and active personal participation in environmental protection and the sustainable use of natural resources. Resolutions' guiding principles highlight a number of important themes, including:
2. Reaffirming that the environment is a common human legacy.
3. Understanding that maintaining, protecting, and improving environmental quality is our shared responsibility in order to advance ecological balance and human health.
4. Making the case for the judicious and sensible use of resources.
5. Stressing the responsibility of each individual to protect the environment by their own behavior and deeds.
6. Outlining the main goals of environmental education, which include improving environmental management and coming up with workable answers to environmental problems.
7. Providing opportunities to acquire the values, information, attitudes, commitments, and abilities required to protect and improve the environment.
8. Encouraging students to examine and evaluate their surroundings via a range of lenses, such as those pertaining to geography, biology, sociology, economics, politics, technology, history, aesthetics, and ethics.
9. Promoting students' environmental awareness and curiosity while encouraging their active participation in resolving environmental concerns.
10. Understanding how environmental education relates to other trans disciplinary issues found in other subject areas.

Types of Environmental Education

Formal Environmental Education

- a) **Structured Environmental Education:** This aspect entails formal training in educational environments and necessitates the inclusion of environmental subjects in the curriculum at various grade levels.
- b) **Environmental Awareness Courses through Distance Learning:** This program helps people have a better understanding of local environmental difficulties by providing them with the opportunity to study specific environmental issues through distance learning programs.
- b) **Environmental Programs at Open Universities:** The Indira Gandhi National Open University (IGNOU) offers flexible study options by facilitating undergraduate degrees through distant education.
- c) **Integrating Environmental Principles into Business and Management Studies:** The Indian Ministry of Human Resource Development required in 2002 that environmental concepts and issues be incorporated into management and business studies curricula, highlighting the significance of environmental literacy in these domains.



**Neeraj Yadav and Lohans Kumar Kalyani****Non-Formal Environmental Education**

- a) **Environmental Clubs:** These are formalized associations that work to raise environmental awareness and take up issues related to the local or global environment within communities, schools, or other organizations.
- b) **The National Environmental Corps** is a government or non-governmental entity entrusted with organizing and carrying out nationwide environmental sustainability and conservation projects.
- c) **Population Awareness Initiatives:** These are plans or initiatives designed to inform people and communities about the environmental effects of population expansion and to encourage responsible family planning.
- d) **Environmental Advocacy Initiatives:** Usually carried out by individuals, organizations, or activist groups, they are attempts to increase public awareness, shape policy, and spur action to solve environmental challenges.
- e) **Global Environmental Initiatives:** These are cross-border international projects or initiatives that tackle environmental issues like pollution, biodiversity loss, and climate change.
- f) **Eco-Friendly Competitions:** These are occasions or competitions that motivate participants to create and present creative approaches or methods that support ecological footprint reduction and environmental sustainability.
- g) **Forums, Conferences, Training Sessions, Camps, Exhibitions, Community Gatherings, Puppetry Performances, and Street Performances:** These are a few examples of platforms or methods that are used to raise awareness of environmental issues, encourage participation and dialogue, and motivate people to take action to improve the environment.

Importance

The health of our planet is intrinsically tied to the well-being of humankind. The capacity of future generations to survive at all rests on our collective shoulders to protect the natural world. This calls for a change in mindset to one of environmental responsibility, in which each person takes an active role in protecting our common environment. A fundamental aspect of this movement involves cultivating a profound comprehension of the complex network of life that keeps us alive. Development is necessary for society to advance, but it cannot come at the price of the environment being worse. Such deterioration frequently results from a lack of public knowledge about the sensitive ecosystem's equilibrium. Environmental problems like as pollution and climate change have effects on people everywhere on Earth, regardless of where they live. As a result, adding environmental education to the curriculum is a crucial first step. We enable the next generation to take on the role of responsible stewards of the planet by teaching them about the environment and its intricate relationships. With this information, they will be able to make decisions that will guarantee a sustainable future for everybody.

Strategies to Increase Awareness

Launched in 1986 by the Indian government's Ministry of Environment and Forests (MOEF), the National Environment Awareness Campaign (NEAC) is a groundbreaking initiative designed to raise environmental awareness among all societal classes. This campaign emphasizes how important awareness is in addressing environmental issues and advancing sustainable development. In order to run its operations, NEAC provides financial support to community organizations, educational institutions, training facilities, and recognized non-governmental organizations (NGOs). These organizations are tasked with carrying out broad public awareness campaigns for Indian citizens, with an emphasis on incorporating environmental education into teacher preparation programs. The MOEF wants people from a variety of backgrounds to have a profound grasp of environmental challenges and its repercussions through NEAC. NEAC makes ensuring that awareness campaigns are decentralized and customized to the particular requirements and circumstances of many areas and communities around the nation by collaborating with NGOs, educational institutions, and community organizations. Additionally, NEAC acknowledges the critical role educators play in influencing the environmental consciousness of coming generations by integrating environmental education into teacher training programs. NEAC's main goal is to spark a national movement in favor of sustainability and environmental care. Through providing people with information, tools, and resources, NEAC works to promote a culture of environmental responsibility and group action. By means of cooperative initiatives and community involvement, NEAC aims to develop a better educated, involved, and ecologically conscious populace that is equipped to tackle the urgent environmental problems of our day.



**Neeraj Yadav and Lohans Kumar Kalyani****Environmental Information System**

The Environmental Information System (ENVIS) has been a key component in the communication of scientific, technical, and semi-technical information on a wide range of environmental concerns since its establishment in 1982–1983 during the Sixth Plan. All levels of government have benefited greatly from ENVIS's assistance in formulating policies and managing the environment, which has aided in the process of making decisions that protect and improve the environment in order to maintain a good standard of living for all living things. Ensuring the smooth integration of national efforts in the gathering, compiling, storing, retrieving, and distribution of web-enabled environmental information to all stakeholders has been the main goal of ENVIS. This includes researchers, scientists, policy planners, decision-makers, and the general public. ENVIS facilitates informed decision-making and effective action for environmental conservation and sustainable development by giving stakeholders access to comprehensive and current environmental data and knowledge resources. Because ENVIS makes it easier for professionals to share their knowledge and experience with practitioners, it is essential in closing the knowledge gap that exists between scientific research and policy implementation. ENVIS promotes the sharing of creative ideas, cutting-edge solutions, and new developments in environmental management and governance through its extensive network of environmental information centres and online platforms. Furthermore, by democratizing access to environmental information, ENVIS encourages accountability, openness, and public involvement in environmental decision-making processes. ENVIS facilitates public access to pertinent data and research findings, enabling citizens to participate in educated discourse, advocacy, and activism for environmental sustainability and protection. All things considered, ENVIS is a crucial instrument in the toolbox of environmental governance, providing knowledge, insight, and foresight to stakeholders as they negotiate the intricate web of environmental possibilities and problems. Through the promotion of cooperation, exchange of ideas, and development of capabilities, ENVIS makes a major contribution to the group's endeavors to create a future that is cleaner, greener, and more resilient for future generations.

The long-term goals of the Plan

1. The Environmental Information System's (ENVIS) goals highlight how important it is to the advancement of environmental science, technology, and information sharing. These goals provide as a foundation for creating a strong repository and dissemination hub that efficiently gathers, processes, stores, retrieves, and distributes environmental data by utilizing cutting-edge technologies. In addition, ENVIS seeks to promote environmental information technology research, development, and innovation, keeping the sector at the forefront of knowledge advancement. In the near future, ENVIS is concentrated on multiple primary goals:
2. Offering a thorough national environmental information service that meets the demands of environmental information processors, users, and disseminators now and in the future. The goal of this service is to handle the changing needs and difficulties in environmental decision-making and management. Improving dissemination, retrieval, and storage capacities to guarantee stakeholders have quick access to environmental data. This entails developing the systems and infrastructure necessary for effective information management and end-user delivery.
3. Encouraging collaboration and national and international cooperation for the sharing of environmental information. ENVIS aims to facilitate cross-border knowledge exchange and collaboration on environmental concerns by cultivating partnerships and networks.
4. Supporting educational and training initiatives designed to improve participants' abilities to process and use environmental information. Efforts to teach professionals and students how to use information technologies for environmental research and decision-making fall under this category.
5. Facilitating information sharing on the environment between developing nations, acknowledging the significance of international collaboration in tackling common environmental issues and advancing sustainable development.
6. By achieving these goals, ENVIS hopes to significantly contribute to the advancement of environmental knowledge, the encouragement of well-informed decision-making, and the development of global cooperation for environmental sustainability. Through the use of technology, encouragement of learning and training, and information sharing, ENVIS helps to create a future that is more sustainable and resilient for everybody.



**Neeraj Yadav and Lohans Kumar Kalyani****Eco-Clubs in Schools**

Eco-Clubs in schools serve as hubs for fostering environmental awareness and action among students. These clubs, found in various educational institutions, engage students in activities like tree planting, waste reduction, and water conservation. Supported by initiatives like the Department of Environment, they educate students on biodiversity, pollution, and sustainable living. Through workshops, clean-up drives, and nature walks, Eco-Clubs instill a sense of responsibility towards the environment and promote community involvement. Empowering the next generation of environmental stewards, Eco-Clubs play a vital role in shaping a more sustainable future. Delhi, the National Capital Territory (NCT), is proud to have established 2000 of these clubs in a variety of educational settings, including colleges and government, assisted, private, and public schools. The Department of Environment provides each school and college Eco Club with an enhanced token grant of Rs. 20,000 to support their environmentally conscious activities. With the help of this funding, a variety of ecologically friendly initiatives can be put into practice, encouraging an eco-aware and action-oriented culture in educational environments.

Activities under this scheme include

1. **Encouraging Tree Plantation:** Motivating students to participate in tree planting activities to maintain green and clean surroundings.
2. **Water Conservation Promotion:** Advocating for the conservation of water resources by minimizing water usage.
3. **Waste Management Advocacy:** Encouraging students to adopt habits and lifestyles that minimize waste generation, promote source separation of waste, and ensure proper disposal to nearby storage points.
4. **Awareness Campaigns against Waste Burning:** Educating students to raise awareness among the public and sanitation workers about the harmful effects of indiscriminate waste burning, which can lead to respiratory diseases.
5. **Reduction of Plastic Bag Usage:** Sensitizing students to minimize the use of plastic bags and discourage their disposal in public places, as they can clog drains, cause waterlogging, and serve as breeding grounds for mosquitoes.
6. **Environmental Education Programs:** Organizing various awareness programs such as quizzes, essays, painting competitions, rallies, and street plays to educate students about environmental issues. Additionally, educating children about the reuse of waste materials and the preparation of products from waste.
7. **Nature Trail Organizing:** Arranging nature trails in wildlife sanctuaries, parks, and forest areas to acquaint students with biodiversity and the importance of conservation efforts.

CONCLUSION

In order to ensure sustainability in education and beyond, it is critical that environmental education be included into teacher training programs. Future educators are given the information, abilities, and attitudes needed to successfully implement environmental education into their teaching practices by including environmental concepts, issues, and practices into teacher education curricula. This all-encompassing strategy not only enables educators to encourage environmental stewardship in their pupils, but it also promotes a sustainable culture in both communities and educational institutions. Ultimately, we can raise a generation of environmentally aware people who can solve environmental issues and help create a more sustainable future for all if we give environmental education top priority in teacher preparation programs.

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Isolation and Characterization of Potash Solubilizing Bacteria from Paddy Rhizosphere Soil

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ABSTRACT

The use of Potassium Solubilizing Bacteria (KSB) as bio-fertilizer has simultaneously increase potash uptake in plants and improve crop production in various crops. A laboratory study was carried out to isolate, identify, and characterize potash-solubilizing bacteria from rhizospheric soil of paddy. The KSB population was greater in paddy rhizosphere soils. Preliminary selection for KSB was based on the establishment of a halo zone surrounding the bacterial colony on Aleksandrov agar medium. The isolated KSB were identified based on their morphological and biochemical characterisers. The isolates showed positive for catalase oxidation and negative for urease. The isolates were Gram-positive rods known as *Bacillus*.

Keywords: Isolation, characterization, Aleksandrov medium, KSB, *Bacillus*.

INTRODUCTION

Potassium is the most important macro key element in the nutrition of plants, next to nitrogen (N) and phosphorus (P). It plays a key function in the activation of numerous metabolic processes like as photosynthesis, protein synthesis, and enzymes, as well as resistance to pest and diseases(1). The amount of soluble potassium content in the soil plays a crucial role in determining its fertility and ability to support plant growth. This soluble potassium is readily available for direct uptake by plants. Meanwhile, the vast majority, between 90-98%, of potassium in soil exists in insoluble forms, including mineral potassium, exchangeable potassium and non-exchangeable potassium (2). Bio fertilizers are biologically active products containing beneficial bacterial or fungal strains, often in easy-to-use as inoculants to enhance soil fertility by adding, conserving and mobilizing nutrients like nitrogen, phosphorus and potassium for better plant growth(3). They also promote soil health and crop quality. While some bacteria function as bio-pesticides to control harmful organisms and others enhance plant growth by producing phytohormones, they are

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not classified as bio fertilizers. Microorganisms are pivotal in the natural K cycle, with rhizobacteria solubilizing potassium in soil. Considerable populations of K-solubilizing bacteria exist in both soil and rhizosphere (4). Several reports revealed the ability of various bacterial species to solubilize insoluble potash minerals, including feldspars, mica, muscovite, potassium aluminosilicate, and biotite. *Bacillus*, *Pseudomonas*, *Klebsiella*, *Acinetobacter*, *Azotobacter*, and *Streptomyces* are among the bacterial genera known for this capacity (5, 6). There is a significant number of potassium-solubilizing bacteria in rhizosphere plant soil. Among these *Pseudomonas*, *Bacillus*, and fungus are the most common soil bacteria. The study investigates the potassium-solubilizing bacteria from rhizospheric soil of paddy, examining their ability to release potassium and enhancing crop nutrition. It aims of the presents study was to identify effective bacteria for solubilizing potassium from different type of unavailable form of potassium, potentially offering an effective KSBto improve soil fertility and increase crop yields with eco-friendly approach.

MATERIALS AND METHODS

Collection of soil sample

Rhizosphere soil samples of paddy were collected from Pudukkottai district. Surface soil was dug to 10cm where the roots of crop were concentrated. From about 0-2.5mm away from the root surface, a zone of soil is located that is significantly influence by living roots and is referred to as the rhizosphere.

Adaptation and enrichment

Collected soil sample were enriched with 5% insoluble potassium and incubated for one weak at room temperature. After adaptation, 1gm of soil was inoculated in 100ml GYF (Glucose Yeast Feldspar) broth and incubated at 37° C on rotary shaker at 120 rpm for 1 week.

Media preparation

Aleksandrov agar medium (AM) was chosen based on the existing reports as a selective medium for the isolation of Potassium Solubilizing Bacteria(7).

Composition of AM medium

Magnesium sulphate	-	0.5g
Potassium alumino silicate	-	0.1g
Glucose	-	5.0g
Ferric chloride	-	0.005g
Calcium phosphate	-	2.0g
Agar	-	20g
Distilled water	-	1000ml
PH	-	7.2±0.

Isolation and screening of KSB

Potassium Solubilizing Bacteria were isolated from soil samples using the serial dilution and spread plate method. Initially, one gram of soil sample was mixed with 10 ml of sterile distilled water and thoroughly shaken. Subsequently, 1 ml of solution from first dilution has transferred to 9ml of sterile distilled water mixed thoroughly. The same procedure was done up to preparing 10⁻⁷dilutions. Each dilution (0.1 ml) was plated onto Aleksandrov agar medium (AM) containing insoluble mica an incubated at Selection of KSB based on halo zone formation 28±2°C for 7 days. Colonies showing halo zones indicative of potassium solubilization were selected and maintained in respective agar sland for further study subjected to two successive subcultures on Aleksandrov agar medium to observe colony morphology. To ensure sterility, the entire procedure was conducted within a laminar airflow (8).

$$\text{Ratio} = \frac{\text{Diameter of zone of clearance (D)}}{\text{Diameter of growth (d)}}$$



**Ranjitha and Alagappan Gandhi****Morphological and biochemical characterization of KSB**

The characterization of isolates involved observing their morphological traits such as shape, margin and colour. Additionally, several biochemical tests were conducted, including Gram staining, Capsule staining, Motility, Catalase oxidation test, MR-VP test, Indole production test, Nitrate reduction, H₂S production, Urease and Starch hydrolysis test.

Cell shape

To observe cell morphology, a loop of bacterial culture was transferred to a glass slide with a drop of sterile water and viewed under a light microscope.

Gram stain

A loopful of 24-36hrs old broth culture of the test bacterium was put on a clean glass slide and air-dried. The slide was then gently heated over the flame of a spirit lamp to fix the bacterial stain. The fixed smear was then immersed in an aqueous Crystal violet solution (0.5%) for 30 to 35 seconds and then rinsed for one minute with a gentle flow of tap water. The stained smear was then flooded for one minute with Gram's iodine solution and gently washed with tap water. Decolourization was done with a 95% ethanol solution until the colour of crystal violet runoff was visible, then washed with a gentle flow of water. Finally, the smear was counterstained with Safranin for about 10 seconds, rinsed with water, air-dried, and examined under a microscope with 40X magnification.

Capsule stain

A capsule stain technique was used to Indian ink method confirm the presence of capsule in the bacterial isolates (9).

Mannitol

motility buds were inoculated with the test organism and cultured at 37°C for 24 hours. Motile species made the medium opaque, but non-motile species grew only along the stab line.

Biochemical characterization

The isolates were essentially subjected to Catalase oxidation test, MR-VP test, Indole production test, Nitrate reduction, H₂S production, Urease and Starch hydrolysis test deamination test were performed by using standard methods(10).

RESULTS AND DISCUSSIONS**Isolation and screening of KSB**

The bacteria were first isolated from rhizospheric soil of paddy using a modified Aleksandrov media containing mica, providing the necessary nutrients and conditions for observing potash solubilizing bacteria. The selected bacteria were screened for their ability to solubilize K minerals, typically evidenced by the formation of clear zones around bacterial colonies, indicating K mineral solubilization. Only colonies displaying distinct morphology and clear zones were chosen, implying they likely possessed the desired solubilization ability. Five bacterial isolates, namely KSB1, KSB2, KSB3, KSB4 and KSB5 were selected based on these criteria. Subsequently, the extent of solubilization exhibited by the chosen isolates was quantified by measuring the diameter of the clear zone around each colony. Notably, isolates KSB1 and KSB2 demonstrated larger zones of solubilization compared to others. The ratio of solubilization zone was measured according to Khandeparkar's selection ratio as listed in (Table 1).

Morphological and biochemical characterization of KSB

The isolates underwent assessment for their capacity to solubilize soluble potassic minerals, while the cultural behaviour of the purified bacterial isolates was observed using Modified Aleksandrov media. Among the five isolates initially tested, only KSB1 and KSB2 were selected for further analysis to tentatively identify and study their morphological and biochemical characteristics, as delineated in (Table 2). KSB1 forms small, opaque, aerobic colonies,



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with small rod-shaped cells and entire margins. These colonies appear creamy in colour and stain positive in Gram staining. They are also capsulated, motile, and positive for catalase, Methyl Red (MR), nitrate reduction, H₂S production and starch hydrolysis, but negative for Vog-es-Proskauer (VP) test, Indole production, and urease activity. In contrast, KSB2 forms medium-sized smooth colonies with short rod-shaped cells and smooth elevated margins. These colonies are creamy white in colour and stain positive in Gram staining. Unlike KSB1, KSB2 lacks capsules and is VP-positive and urease-positive but Indole-negative. Additionally, KSB2 does not reduce nitrate or produce H₂S.

Identification of isolated bacteria

On the basis of different morphology and biochemical analysis performed the isolated bacterial strain KSB1 and KSB2 were identified as bacillus(Plate 1). The results of present study obtained on morphological and biochemical characteristics of KSB1 and KSB2 are conformity with earlier reports of several workers (8, 10, 11, 12, 13, and 14).

CONCLUSION

Potassium availability to crop plants in soil is generally low since nearly 98% of total K in soil is in mineral form. Solubilization of soil mineral potassium by bacteria is well established. Rhizosphere micro-organisms contribute significantly in solubilization of bound form of minerals in the soil. The results obtained from the current study concerning isolation, screening and characterization of two isolates of KSB from some paddy rhizosphere soil revealed that bacillus species can potentially enhance the dissolution of K-bearing minerals the best isolate with the highest score in Aleksandrov agar were KSB2 (2.08cm diameter). Even though the isolate KSB2 showed maximum solubilizing potentiality in laboratory condition further studies on the mechanism by which KSB solubilize mica and the effectiveness of their use in the fields is needed.

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Table: 1 Potassium Solubilization Values of Bacterial Isolates by Khandeparkar's Selection Ratio

Isolates	Diameter of zone clearance (D)mm	Diameter of growth (d)mm	D/d ratio
KSB1	8.3	4.2	1.98
KSB2	11	5.3	2.08
KSB3	7.1	6.7	1.06
KSB4	6.5	5	1.3
KSB5	5.4	4.3	1.25

Table: 2 Colony, Morphological and biochemical characteristic of best potassium solubilizing bacterial (KSB) isolates.

Isolate	KSB1	KSB2
Colony characters	Small, opaque, aerobic	Medium, smooth, aerobic
Shape	Small Rod	Short rod
Margin	Entire	Smooth elevated
Colour	Creamy	Creamy white
Grams stain	Positive	Positive
Capsule stain	Capsulated	Non capsulate
Motility	Motile	Motile
Catalase test	+	+
MR	+	+
VP	-	+
Indole production	-	-
Nitrate reduction	+	-
H₂S production	+	-
Urease	-	+
Starch hydrolysis	+	+

(+) positive; (-) negative





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Plate :1





Phytochemical Screening, HPTLC Finger Printing Profile, GC-MS Analysis and Evaluation of Anticancer Potential of Methanolic Extract of *Helianthus annuus* Seeds against Lung cancer (A549), Cervical Cancer (HeLa), Breast Cancer (MCF-7) and Bone Cancer Cell Line (MG63) by *In Vitro* Cytotoxicity Assay

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ABSTRACT

The aim of the present study to evaluate the phytochemical screening, HPTLC Finger printing profile, GC- MS analysis and In- Vitro anticancer potential in the methanolic extract of *Helianthus annuus* seeds against Lung , Cervical, Breast and Bone cancer cell line. The preliminary phytochemical screening showed that the most of the active compounds were mainly found in methanolic extract of *Helianthus annuus* seeds. Especially bioactive compounds such as Alkaloids, Flavonoids, Phenols, Saponin and Tannin were highly present in the methanolic extract when compared to other solvents like Chloroform, Ethyl acetate Petroleum ether and Aqueous extract based on the solubility. HPTLC analysis study revealed that flavonoids compounds were found as identified fraction in the methanolic extract of seeds. when compared with standard Quercetin compounds. Essential active compounds have been identified in the methanolic seed extract of *Helianthus annuus* by using GC-MS Technique. GC- MS results revealed that some of the vital compounds were identified as different peak with different molecular weight and RT value. Four different cancer cell lines such as Lung, Cervical. Breast and Bone cancer cell line have been treated with plant drug MEHA. The percentage of cancer cell viability were decreased and increased cancer cell cytotoxicity were observed in maximum concentration of plant drug in four cancer cell lines by MTT Assay .This review focus methanolic seed extract of *Helianthus annuus* as therapeutic potential against cancer and hence proved that it can be used alone or in combination with chemotherapeutic drugs in future.

Keywords: *Helianthus annuus* seeds, HPTLC, Quercetin, GC-MS , MTT assay , A549 cell line, HeLa cell line, MCF-7 cell line & MG-63 cell line



**Aanoorvanitha and Siva Ganesh****INTRODUCTION**

A traditional medicine possess plant-based properties as a good remedy for various diseases. A scientific research to develop anticancer drug from herbal plants began from 19th century [1] WHO reportedly analyzed that more than 75 % of the population in underdeveloped nations relies on natural traditional herbs as a best source for medication. Since ancient times, medicinal therapeutic herbs, often known as herbal medicine, have been identified and applied in traditional medical practices[2]. Therapeutic potential of Indian traditional plants are globally used by all type of people as folk medicines like Siddha, Ayurveda, and Unani. 85% of the world's people depend on natural traditional drug for their primary healthcare needs. The significance of natural medicinal plants to human health is enormous[3]. Chemotherapy using allopathic drugs can produce severe harmful side effects and hence its usage has been constricted [4]. Cancer is a second leading cause of deaths in worldwide[5]. Different type of cancer like Lung cancer, Breast cancer, Stomach cancer, Prostate cancer, Skin cancer, Liver cancer and Stomach cancer etc caused by environmental factor, stress, life style and genetical factor [6]. The recent research reports revealed that the arresting and delaying the tumor growth carried out by the bioactive compounds derived from traditional medicinal plants [7]. The vital advantages of herbal based medicines are their safety and affordable [8]. *Helianthus annuus* (Asteraceae) is an important oilseed crop around the world. *Helianthus annuus* is a widely growing plant which is used traditionally as an, antimalarial, antimicrobial anti-asthmatic, anti-inflammatory anti-oxidant, and anti-tumor activity.[9] It has been utilized as medicines for thousands of years and now there is a growing demand for plant-based medicines, health products, pharmaceuticals and cosmetics. Methanolic decoction of root part of *Helianthus annuus* has been used for rheumatic disorders [10]. The seed part of sunflowers are often taken raw or preferred to be eaten roasted because they are rich source of Vitamins A, D, E K. and Protein. Research studies have revealed that it can prevent us from cancer and many more harmful diseases.

MATERIALS AND METHODS**Collection of plant materials**

The seeds of *Helianthus annuus* were collected from the local area of Kangeyam and Tirupur, Tamil Nadu. Seed part of the plants were prepared for different solvent extractions such as Methanol, Ethyl acetate, Petroleum ether, Chloroform and Aqueous for sample analysis.

Preparation of plant extract

25 gm of plant seed MEHA was dissolved in 250 ml of Methanol, Ethyl acetate, Chloroform, Petroleum ether and Aqueous and kept it in a shaker for 24 hours. The extract was filtered through Whatmann No 1 filter paper and residue was collected. The filter was concentrated using a rotator vacuum evaporator to get methanol extract of the dried plant powder.

Soxhlet Extraction

The Soxhlet extraction process is ultimately needed where the desired active compounds has a limited solubility in a solvent, and the impurity is insoluble in that solvent. If the desired compound has a high solubility in a solvent then a simple filtration can be used to separate the compound from the insoluble substance.[11]

PHYTOCHEMICAL ANALYSIS

Phytochemical studies were performed for observing the secondary metabolites present in the different extracts using procedures described by Trease and Evans[12] The preliminary qualitative phytochemical studies were performed for testing the different active compounds present in different extracts.

Detection of Alkaloids

Extracts were dissolved individually dilute Hydrochloric acid and filtered.





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Mayer's test

Filtrates were treated with Mayer's reagent (Potassium mercuric iodide). Yellow coloured precipitate indicates presence of alkaloids.

Wagner's test

Filtrates were treated with Wagner's reagents(Iodine and Potassium iodide) for identification of alkaloids.

Detection of Flavonoids

Alkaline reagent test

Extracts were treated with few of drops of sodium hydroxide solution. Formation of intense yellow color, which became colorless on addition of dilute acid, indicates the presence of flavonoids.

Lead acetate test

Extracts were treated with few drops of lead acetate solution. Formation of yellow colour precipitate indicates the presence of flavonoids.

Detection of Phenols

Ferric chloride test

Extracts were treated with 3-4 drops of ferric chloride solution. Formation of bluish black color indicates the presence of phenols

Detection of Glycosides

Extracts were hydrolyzed with dil. HCL , and then subjected to test for glycosides

Modified Borntrager's test

Extracts were treated with ferric chloride and immersed in boiling water bath for about 5 minutes. The mixture was cooled and extracted equal volumes of benzene. The benzene layer was separated and treated with ammonia solution. Formation of rose-pink color in the ammonia layer indicates the presence of anthranilic glycosides

Legal's test

Extract were treated with sodium nitroprusside in pyridine and sodium hydroxide. Formation of pink to blood red color indicates the presence of cardiac glycosides

Detection of Saponins

Foam test

0.5 gm of extract was shaken with 2ml of water. If foam produced persists for ten minutes it indicates the presence of saponins

Detection of Tannins

3-5ml of test solution with few drops of 1ml lead acetate and observed red precipitate was observed and indicates the presence of tannin

Detection of Phytosterols

3 ml of test solution and minimum quantity of chloroform was added with 1-4 drops of acetic anhydride and one drop of concentrated nitric acid

Detection of Proteins

Xanthoproteic test

The extracted were treated with few drops of Conc. Nitric acid. Formation of yellow colour indicates the presence of protein



**Aanoorvanitha and Siva Ganesh****Detection of Diterpenes****Copper acetate test**

Extracts were dissolved in water and trail willy 3-4 days drops of copper acetate solution. Formation of emerald green colour indicates the presence of diterpenes.

HPTLC –HIGH PERFORMANCE THIN LAYER CHROMATOGRAPHY

Thin Layer Chromatography was applied to separate the flavonoid compounds to identify and quantify the active compounds compared with standard Quercetin. HPTLC is an unique analytical technique it is rapid, visual, and economical as it utilizes smaller volumes of solvents with minimum sample. Above all, in a short duration, a large number of samples are evaluated simultaneously in a short duration[13] 20mg was weighed accurately in an electronic balance (Afcoset), dissolved in 250 µl of the respective solvent and centrifuged at 3000rpm for 5mins. This solution was used as test solution for HPTLC analysis. 2µl of test solution and 2 µl of standard solution were loaded as 5mm band length 3 x 10 silica gel 60F254 TLC plate using Hamilton syringe and CAMAG LINOMAT 5 instrument. The samples loaded plate was kept in TLC twin through developing chamber (after saturated with solvent vapor) with respective mobile phase and the plate was developed up to 90mm. The developed plate was dried by hot air to evaporate solvents from the plate. The plate was kept in photo documentation chamber(CAMAG REPROSTAR 3) and captured the images at visible light, U 254nm and UV 366nm. The developed plate was photo-documented in visible light and UV 366nm mode using photo-documentation (CAMAG REPROSTAR 3)chamber. After derivatization, the plate was fixed in scanner stage(CAMAG TLC SCANNER 3) and scanning was done at UV 366nm. The peak table, peak display and peak densitogram were noted.

Gas Chromatography/Mass Spectrometry (GC/MS)

It is a common essential technique and used to make an effective chemical analysis. First step of GC/MS was started by injecting the sample to the column of the gas chromatography (GC) device. A mixture compounds will separate into simple substances when heated. Heated gas compounds were carried through a column with an inert gas. The test drug was evaporated in the junction part of the GC technique and segregated in the column by adsorption and desorption technique with suitable temperature which is controlled by software tools. Separation of the eluted components depends on the boiling point of the individual components.[14,15,16].

INVITRO CYTOTOXICITY ASSAY-MTT Assay**Principle**

MTT 3-(4, 5-dimethylthiazol-2-yl)- 2, 5diphenyl tetrazolium bromide enters into the cells and reacts with mitochondrial enzymes where it reduced into insoluble colored (dark purple) formazan product. The formazan crystal within the cells is then solubilized with an organic solvent DMSO and the released solubilized purple color formazan reagent is measured spectrophotometry at 570nm.

MTT Assay

Anticancer assay is carried out for the given test samples by selecting a culture flask with 85- 90% confluences. After trypsinization and centrifugation the cancer cells are seeded in the well plate for one day at 37°C incubation to form a monolayer. The culture medium from the cancer cells is replaced with fresh medium Test sample at different concentration in triplicates were added to the cells. After the incubation of sample with cells at 37°C for 18-24 hrs., MTT (1 mg/ml) were added in all the wells and incubated for 4 hrs. After the time interval DMSO is poured on the wells and read at 572 nm using spectrophotometry method. The percentage of cytotoxicity was calculated using standard formula.[17]

Cytotoxicity = [(Control – Treated)/ Control] X100

Cell viability= (Treated / Control) X 100





RESULTS AND DISCUSSIONS

Phytochemical screening

Various solvent extracts like Methanol, Ethyl acetate, Chloroform, Petroleum ether and Aqueous extracts of the seed part of *Helianthus annuus* showed the presence of secondary metabolites such as Alkaloids, Flavonoids, Phenols, Tannins, Saponin and Phytosterols reported that the most of the secondary metabolites found in MEHA when compared to other solvents.

HPTLC Finger Printing Profile

HPTLC analysis study revealed that flavonoids compounds were found as identified fraction in the methanolic extract of seed part of *Helianthus annuus*. HPTLC finger printing analysis study showed that the identification of flavonoids found in the separated fractions compared with the standard compounds quercetin captured the images at visible light, UV 254nm and UV 366nm respectively. The methanolic extract of the plant *Helianthus annuus* seeds has the excellent pattern of flavonoids identified by using HPTLC technique.

Identification of Bio active compounds of MEHA by using GC-MS Technique

The identification of different peaks with retention time of MEHA were analyzed by GC-MS technique. The methanolic extract of *Helianthus annuus* seeds showed that many active compounds were found in different peak area with RT value. Bufotalin identified in a higher peak 7.30 and RT value was 15.78 present in the sample in which is the most prominent constituent of *Helianthus annuus* seeds and also identified another compound 6-Fluoro-4-hydroxycoumarin has possessed in a peak area 3.80 and RT value was 6.28. The recent research reported that the same active group compounds such as mono terpenoid phenol – Thymol found in volatile ethanolic extraction of the seed part of *Apium leptophyllum* (Pers) belongs to Apiaceae family possessed highest peak area was 96.36% through GC-MS Analysis technique.[18] GC-MS result showed that the presence of several active compounds found in MEHA it may be better anticancer activity for various cancer cell line.

In- Vitro Cytotoxicity Assay –A549 cell line, HeLa cell line, MCF-7 cell line & MG-63 cell line by MTT assay:

The methanolic extract of *Helianthus annuus* showed mild to severe cytotoxicity in HeLa cancer cell line after 24hrs. The higher concentration of plant drug has excellent cytotoxic activity in Cervical cancer, Bone cancer, Lung cancer and Breast cancer cell line respectively. The increased level of cytotoxicity was found in Cervical cancer cell line when compared to other cancer cell line. The decreased cancer cell viability based on the dose dependent manner and the life span of cancer cell viability totally decreased due to the higher concentration of secondary metabolites present in MEHA. The cancer cell viability for HeLa, MG63, A549 and MCF-7 were completely decreased as 18%, 24%, 27% & 34% respectively in a maximum concentration of plant drug MEHA. The increased percentage of cell cytotoxicity found as 82% in HeLa and 76% in MG63 cell line in a maximum concentration up to 100µg methanolic extract of *Helianthus annuus* seeds. In the same observation related to the ethanolic extract of *Nigella sativa* seed possess the increased cytotoxicity in HeLa cell line and A549 cell line in a maximum concentration of 100µg based on dose dependent manner by MTT assay.[19] Results revealed that the methanolic solvent extract possess the higher solubility and better active constituents for different type of cancer cell line. The result concluded that the methanolic solvent extract of the plant compounds might be a better drug formulation for various type of cancer alternative to chemotherapy in future aspects.

SUMMARY AND CONCLUSION

Phytochemical analysis reported that the most of active compounds were highly found in the methanolic extract of plant seed *Helianthus annuus* when compared to other solvent extracts based on the solubility. The identified fraction of the active compounds flavonoids were identified in MEHA when compared to standard compounds quercetin in two different range as UV 254nm and UV 366nm by HPTLC technique. It could be better drug for the evaluation of cancer studies. The methanolic extract of the plant has the excellent pattern of flavonoids identified for further analysis. The identification of different peaks with retention time of MEHA were analyzed by GC-MS technique. GC-MS result showed that the presence of several active compounds found in MEHA it may be better anticancer





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activity for various cancer cell line . The methanolic extract of *Helianthus annuus* enhanced the anticancer activity in different cancer cell lines by MTT assay. The increased percentage of cytotoxicity were observed in Cervical cancer , Bone cancer , Lung cancer and Breast cancer cell lines and also evaluated decreased cancer cell viability in a maximum concentration of plant drug in 100µg MEHA by MTT assay. The higher concentration of plant drug has an excellent cytotoxicity activity in both cervical cancer cell line and bone cancer cell line. Herbal drugs are derived from natural medicinal plants it does not lead to any adverse and side effect to our human body. Finally, it is hoped that this review would be a source of guidance and support for the thirst of researchers to conduct further preclinical and clinical studies through herbal medicine for the treatment of cancer.

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Disclosure & Conflicts of interest

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Table 1:Phytochemical screening of *Helianthus annuus* seeds Extracts

	MTHANOL	AQUEOUS	PETROLUEM ETHER	CHLOROFORM	ETHYL ACETATE
ALKALOIDS	+	-	-	-	+
FLAVONOIDS	++	+	+	+	+
PHENOL	++	+	+	+	+
PHYTOSTEROL	++	-	+	+	+
SAPONINS	+	+	+	-	-
TANNINS	+	-	+	-	-
DITERPENES	++	+	-	+	+
GLYCOSIDES	+	-	-	+	-
PROTEINS	+	-	-	+	+

Table : 2

S.NO	Standards/ sample extract	Retention time (min)	Area [mAU]	Area (%)	CONCENTRATION (mg/kg)	
1	QUERCETIN	0.93	6658.9	100	20	
2	Methanolic Extract of Sunflower Seed	Flavonoids	0.90	489.7	22.21	Present
		Proximate Quantification	Methanolic Extract of Sunflower seed contains Quercetin= 1.47 mg/kg			

Table -3- Bone Cancer cell line – MG63

Concentration(µm)	Liquid-Sunflowerseedextraction		
Concentration(µg)	Cytotoxicity(%)	Cellviability(%)	Reactivity
5	47	53	Mild
25	56	44	Moderate
50	64	36	Moderate
75	70	30	Moderate
100	76	24	Severe

Table -4- Cervical Cancer cell line – HeLa

CONCENTRATION(µm)	-Sunflower seeds extraction		
Concentration(µg)	Cytotoxicity(%)	Cellviability(%)	Reactivity
Concentration(µg)			





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5	38	62	Mild
25	49	51	Mild
50	73	27	Severe
75	76	24	Severe
100	82	18	Severe

Table -5- LungCancer cell line – A549

CONCENTRATION(µm)	Sunflower seeds extraction		
	Cytotoxicity(%)	Cellviability(%)	Reactivity
Concentration(µg)			
5	22	78	Mild
25	38	62	Mild
50	59	41	Moderate
75	67	33	Moderate
100	73	27	Severe

Table -6- Breast Cancer cell line – MCF-7

CONCENTRATION(µm)	Liquit-Sunflower seeds extraction		
	Cytotoxicity(%)	Cellviability(%)	Reactivity
Concentration(µg)			
5	24	76	Mild
25	32	68	Mild
50	50	50	Mild
75	57	43	Moderate
100	66	34	Moderate

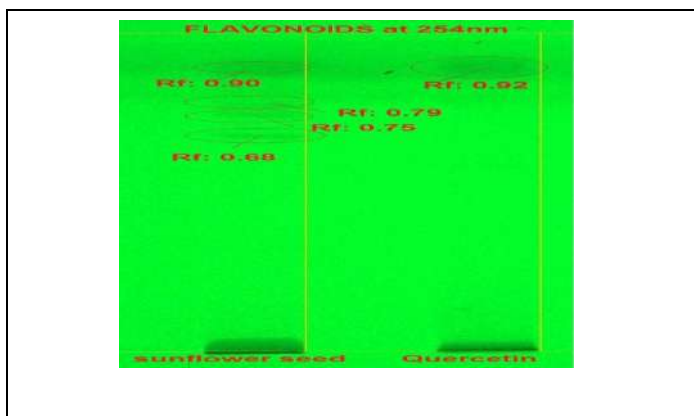


Figure 1: HPTLC Photo documentation of Flavonoid standard Quercetin and methanolic Extract of plant sample MEHA at 254nm

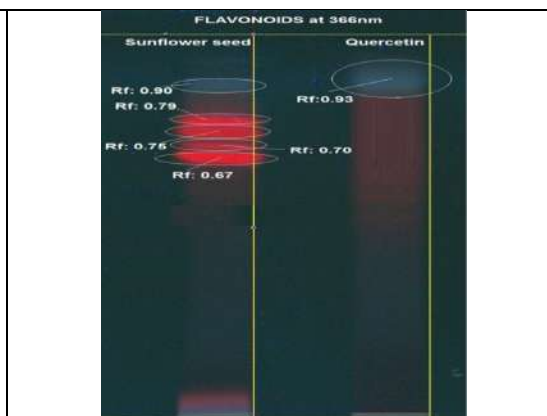


Figure 2: HPTLC Photo documentation of Flavonoid standard Quercetin and methanolic Extract of plant sample MEHA at 366 nm





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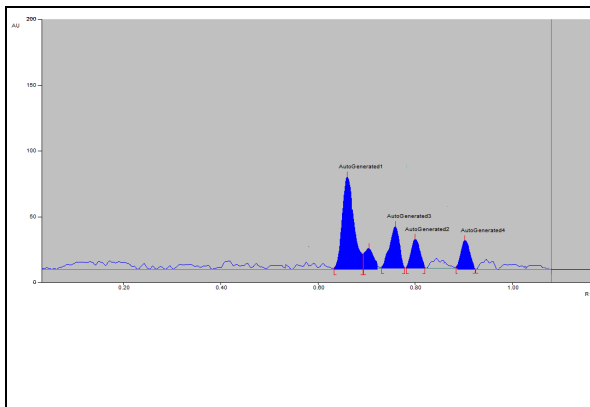


Figure 3: The Chromatogram of Ethanolic Extract of plant sample MEHA

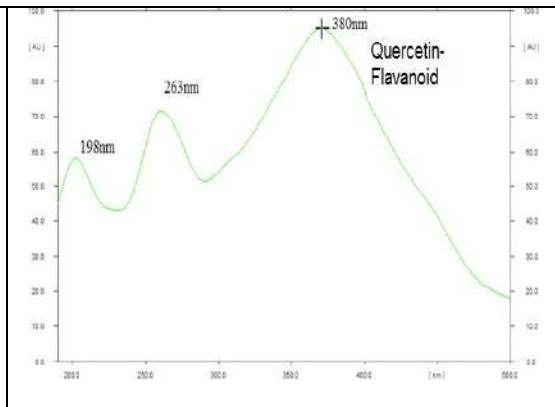


Figure 4: The UV-Vis matched Spectrums of Flavonoid standard and sample

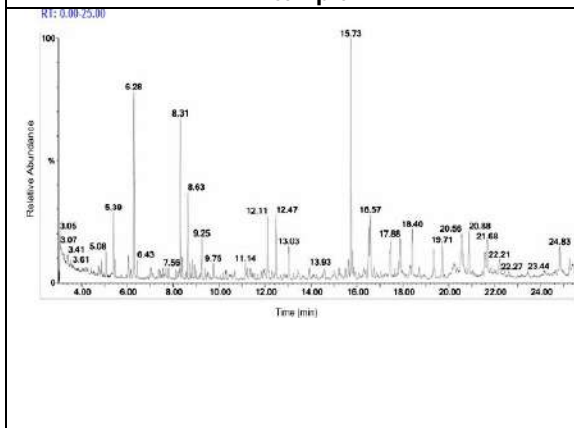


Figure -5 : GC- MS ANALYSIS OF Methanolic extract of Helianthus annuus seeds

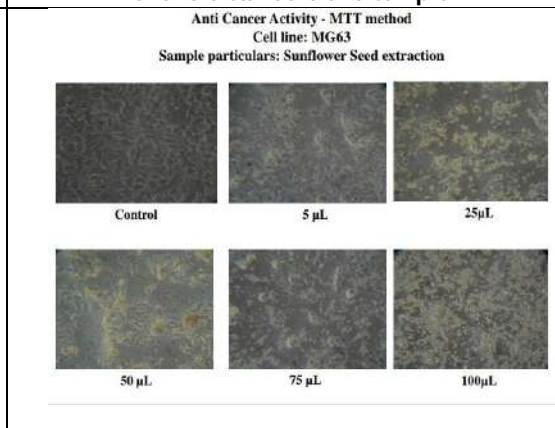


Figure -6: Bone Cancer cell line – MG63

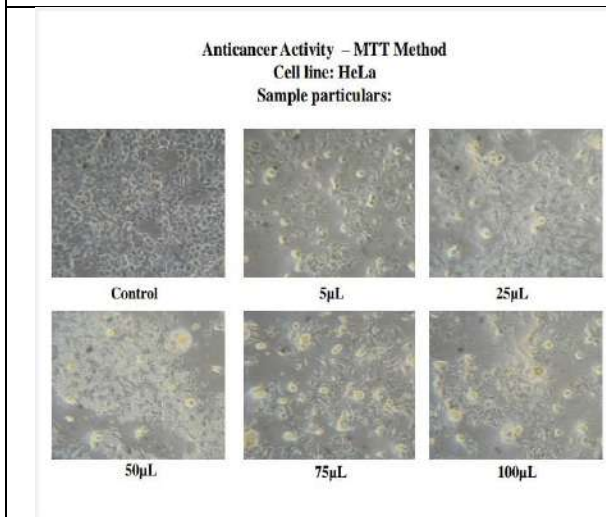


Figure -7: Cervical Cancer cell line – HeLa

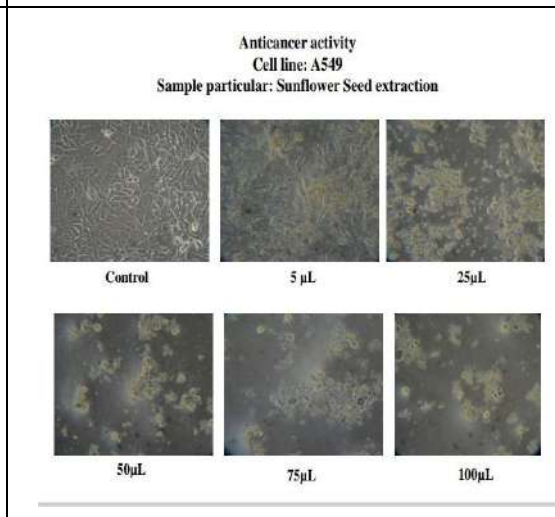
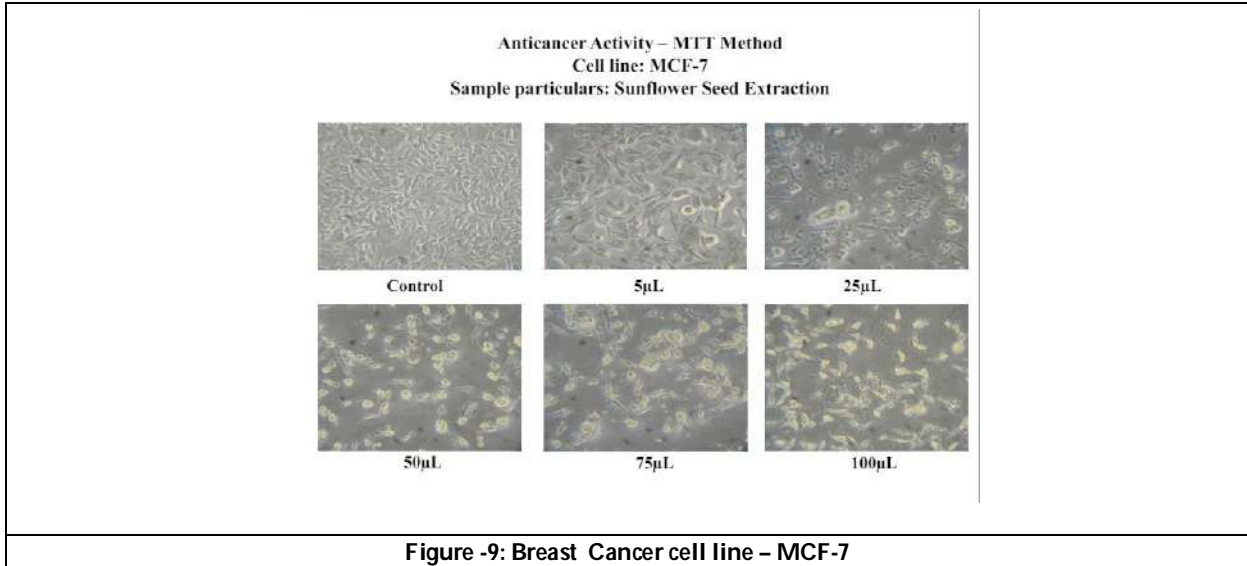


Figure -8: Lung Cancer cell line – A549





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Analysing the Barriers Influencing Students' Preference for Studying Science Subjects using Trapezoidal Fuzzy Cognitive Map

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ABSTRACT

This study investigates what influences students' interest in science by using fuzzy logic and cognitive mapping. It provides insights into the influence of several factors on decisions about science education by modelling complex relationships between fear, difficulty, lack of interest, understanding, math ability, financial restrictions, career prospects, job uncertainty, and limited awareness. Interdependent barriers to students' decision-making in science subjects are identified by the research through an extensive assessment of the literature and empirical analysis. With the help of the Trapezoidal Fuzzy Cognitive Map (TFCM) (*Trapezoidal fuzzy cognitive map*) model, the research provides nuanced understandings of the uncertainties affecting students' resistant behaviour. The research is valuable for academics, educators, and politicians since it emphasizes the need for focused initiatives to remove obstacles and improve the STEM (*science, technology, engineering, and mathematics*) education environment. The TFCM method is essential for making well-informed judgments, especially considering the importance society has placed on STEM fields. For more accurate results, we used the eigenvalues approach. It offers significant insights into the intricate relationships and preferences concerning the barriers affecting students' inclination towards studying science.



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Keywords: Fuzzy Cognitive Maps (FCMs), Trapezoidal Fuzzy Cognitive Maps, Eigen values, STEM (science, technology, engineering, and mathematics).

INTRODUCTION

In today's rapidly evolving educational landscape, the importance of understanding the factors shaping students' preferences for studying science subjects cannot be overstated. With societies increasingly reliant on innovation and technological advancement, the significance of science, technology, engineering, and mathematics (STEM) education has gained prominence. However, despite the recognition of STEM fields' importance, students' inclination towards science-related courses can encounter obstacles and uncertainties. This paper endeavours to explore the intricate decision-making processes guiding students' choices in science education, employing sophisticated methodologies grounded in fuzzy logic and cognitive mapping. By scrutinizing the intricate interplay between factors such as fear, difficulty, lack of interest, understanding, math ability, financial constraints, career prospects, job uncertainty, and limited awareness, this research aims to unearth the interconnected barriers influencing students' preferences for science subjects. Through a meticulous examination of existing literature and empirical analysis, this study seeks to offer nuanced insights into the uncertainties contributing to students' reluctance towards science education. Leveraging the Trapezoidal Fuzzy Cognitive Map (TFCM) model facilitates a thorough exploration of the multifaceted influences on students' interest in science, providing a deeper comprehension of the underlying dynamics. The implications of this research are anticipated to be profound for various stakeholders, including academics, educators, and policymakers. By emphasizing the necessity for targeted interventions to dismantle barriers and improve the STEM education ecosystem, this study underscores the importance of nurturing an environment conducive to fostering students' engagement and involvement in science-related disciplines.

Furthermore, amidst society's increasing emphasis on STEM fields, the adoption of the TFCM method represents a pivotal advancement in formulating informed strategies for promoting STEM education. By harnessing the benefits of the trapezoidal fuzzy approach over conventional methodologies, this study aims to offer more precise and actionable insights into addressing the challenges impeding students' affinity towards science subjects. In essence, this research endeavors to illuminate the complex dynamics shaping students' interest in science education, with the overarching goal of contributing to the advancement of STEM education initiatives and cultivating a workforce equipped with the requisite skills and knowledge to thrive in an era characterized by technological innovation and progress. In the wake of COVID-19, students are changing how they approach science classes due to changes in career interests and a need for practical application. Interest in robust fields that handle pandemic-related issues, like technology and healthcare, has increased because of the epidemic. A greater understanding of the effectiveness of online learning has caused some students to select courses that are more appropriate for digital platforms. Students now tend to choose courses that they believe will lead to better work opportunities due to uncertainty in the labour market. Students are choosing to study subjects that are in line with their passions due to concerns about their mental health. Technology and information science jobs have become more attractive due to the trend of remote employment. Essentially, students' views on scientific courses in the post-COVID period are shaped by pragmatic concerns, career re-evaluations, and the need to see real-world applications.

LITERATURE SURVEY

In 1965, Lotfi A. Zadeh introduced Fuzzy Cognitive Maps (FCMs) as a mathematical model [1]. Kosko further enhanced cognitive maps by incorporating fuzzy values for concepts and fuzzy degrees of interrelationships between them in 1986 [2]. In 1976, political scientist R. Axelrod popularized FCMs for representing social scientific knowledge and described their use in decision-making within social and political systems [3]. W.B. Vasantha Kandasamy and Smarandache Florentin applied Fuzzy Theory and Neutrosophic Cognitive Maps in 2000 to analyse social aspects of migrant labourers living with HIV/AIDS [4], [5]. In 2013, M. Clement Joe Anand and A. Victor Devadoss introduced





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Triangular Fuzzy Cognitive Maps (TrFCM) to analyse the causes of divorce within families [6].A. Saraswathi and A. Praveen Prakash (2014) investigated problems faced by transgender individuals in India using New Triangular Fuzzy Cognitive Maps (TrFCM) [7]. A. Praveen Prakash and J. Esther (2014) applied Trapezoidal Fuzzy Cognitive Maps to rank problems experienced by deprived rural individuals with disabilities [8]. Kanimozhi Raman (2014) applied Induced Trapezoidal Fuzzy Cognitive Maps to address issues faced by the elderly [9].In 2007, Shi-Jay Chen and Shyi-Ming Chen proposed a fuzzy risk analysis method based on the ranking of generalized trapezoidal fuzzy numbers [10].

Basic Definitions

Definition 1

A fuzzy subset $A \subseteq X$ can be defined by its membership function μ_A , where $\mu_A: X \rightarrow [0,1]$. (i.e) $A = \{(x, \mu_A(x)) \mid x \in X\}$.

A fuzzy set is a set where each element in the universe of discourse is assigned a value indicating its degree of membership in the set. The numerical value assigned by a membership function to an element of a fuzzy set, indicating the strength of its membership in $[0,1]$

Definition 2

Given a fuzzy set A defined on X and any number $\alpha \in [0,1]$. The α -cut of a fuzzy set A is denoted by ${}^\alpha A$ and is defined by

$${}^\alpha A = \{x \in X \mid A(x) \geq \alpha\}.$$

The Strong α -cut of a fuzzy set A is denoted by ${}^{\alpha+} A$ and is defined by

$${}^{\alpha+} A = \{x \in X \mid A(x) > \alpha\}.$$

Trapezoidal fuzzy membership for the linguistic values :

Influences students' interest in science by using fuzzy logic and cognitive mapping provides insights into the influence of several factors on decisions about science education by modelling complex relationships between fear, difficulty, lack of interest, understanding, math ability, financial restrictions, career prospects, job uncertainty, and limited awareness. Fear is one of the linguistic variable and the values of this variable are very low, low, medium, high and very high.

Trapezoidal fuzzy membership for the linguistic values are

Very low	(0,0.1,0.1,0)
Low	(0.1,0.25,0.25,0.1)
Medium	(0.25,0.5,0.5,0.25)
High	(0.5,0.75,0.75,0.5)
Very high	(0.75,1,1,0.75)

Cognitive Matrix

A cognitive matrix is a structured representation of cognitive information, typically organized in a tabular format. In the context of cognitive science, psychology, and artificial intelligence, cognitive matrices are used to represent relationships, associations, or connections between different elements or concepts.

Analysis of the problem

Interdependent barriers to students' decision-making in science subjects are identified by the research through an extensive assessment of the literature and empirical analysis. The following characteristics were identified from research specialists to aid in the problem analysis.

1. C₁- Fear
2. C₂ -No Career and Job
3. C₃-Lack of Awareness
4. C₄ -Hardness





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- 5. C₅- Lack of Interest
- 6. C₆-Lack of Math Ability
- 7. C₇-Lack of Finance
- 8. C₈ -Lack of Understanding

Utilizing the specialist's understanding of indeterminacy as a foundation, we have used the Trapezoidal cognitive matrix to Analysing Barriers Influencing Students' Preference for Studying Science.

METHODOLOGY

Step 1: Form cognitive matrix which is used to represent relationships, associations, or connections between different elements or concepts. the relationships and preferences regarding the barriers influencing students' choice to study science. Each cell contains a relationship strength (e.g., V.H for Very High, M for Moderate, V.L for Very Low), reflecting the cognitive perceptions among the mentioned factors.

Step 2: Assign trapezoidal fuzzy membership from [0,1].
Trapezoidal fuzzy membership for the linguistic values are

Very low	(0,0.1,0.1,0)
Low	(0.1,0.25,0.25,0.1)
Medium	(0.25,0.5,0.5,0.25)
High	(0.5,0.75,0.75,0.5)
Very high	(0.75,1,1,0.75)

Step 3: Employ the α -cut formula to calculate a specific cut of the trapezoidal fuzzy number using a parameter α (set at 0.5 in this case).

$${}^\alpha A = [a + \alpha(b - a), d - \alpha(d - c)] = [f, g]$$

Step 4: Defuzzification takes the fuzzy output produced by the fuzzy inference process and converts it into a single crisp value that can be easily understood and used in decision-making. Here we defuzzify [f,g] using the average (f+g)/2.

Step 5: Compute the eigenvalues of the defuzzified matrix A using the eig(A)function in MATLAB.

Step 6: Taking the modulus ensured that the values obtained were positive, after which ranking was assigned accordingly. This straight forward approach allows you to calculate and display both the matrix and its corresponding eigenvalues in MATLAB.

C₁ C₂ C₃ C₄ C₅ C₆ C₇ C₈

$$\begin{matrix}
 C_1 \\
 C_2 \\
 C_3 \\
 C_4 \\
 C_5 \\
 C_6 \\
 C_7 \\
 C_8
 \end{matrix}
 \begin{bmatrix}
 - & VH & VH & VH & VH & VL & VL & VL \\
 VH & - & H & VH & VH & M & VL & M \\
 VH & H & - & VH & VH & M & VL & M \\
 VH & VH & VH & - & VH & M & VL & M \\
 VH & VH & VH & VH & - & M & H & H \\
 VH & M & M & M & M & - & H & M \\
 VL & VL & VL & VL & H & H & - & M \\
 VL & M & M & M & H & M & M & -
 \end{bmatrix}$$

Cognitive matrix





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	TrpC ₁	TrpC ₂	TrpC ₃	TrpC ₄	TrpC ₅	TrpC ₆	TrpC ₇	TrpC ₈
TrpC ₁	–	0.875	0.875	0.875	0.875	0.05	0.05	0.05
TrpC ₂	0.875	–	0.625	0.875	0.875	0.375	0.05	0.375
TrpC ₃	0.875	0.625	–	0.875	0.875	0.375	0.05	0.375
TrpC ₄	0.875	0.875	0.875	–	0.875	0.375	0.05	0.375
TrpC ₅	0.875	0.875	0.875	0.875	–	0.375	0.625	0.625
TrpC ₆	0.875	0.375	0.375	0.375	0.375	–	0.625	0.375
TrpC ₇	0.05	0.05	0.05	0.05	0.625	0.625	–	0.375
TrpC ₈	0.05	0.375	0.375	0.375	0.625	0.375	0.375	–

Table 1 : Defuzzified matrix Eigen values of defuzzified matrix are calculated using MATLAB

```

>> % Define the matrix A
A = [
    0      0.875  0.875  0.875  0.875  0.05  0.05  0.05;
    0.875  0      0.625  0.875  0.875  0.375  0.05  0.375;
    0.875  0.625  0      0.875  0.875  0.375  0.05  0.375;
    0.875  0.875  0.875  0      0.875  0.375  0.05  0.375;
    0.875  0.875  0.875  0.875  0      0.375  0.625  0.625;
    0.875  0.375  0.375  0.375  0.375  0      0.625  0.375;
    0.05  0.05  0.05  0.05  0.625  0.625  0      0.375;
    0.05  0.375  0.375  0.375  0.625  0.375  0.375  0
];
disp('Matrix A:');
disp(A);

Matrix A:
    0      0.8750  0.8750  0.8750  0.8750  0.0500  0.0500  0.0500
    0.8750  0      0.6250  0.8750  0.8750  0.3750  0.0500  0.3750
    0.8750  0.6250  0      0.8750  0.8750  0.3750  0.0500  0.3750
    0.8750  0.8750  0.8750  0      0.8750  0.3750  0.0500  0.3750
    0.8750  0.8750  0.8750  0.8750  0      0.3750  0.6250  0.6250
    0.8750  0.3750  0.3750  0.3750  0.3750  0      0.6250  0.3750
    0.0500  0.0500  0.0500  0.0500  0.6250  0.6250  0      0.3750
    0.0500  0.3750  0.3750  0.3750  0.6250  0.3750  0.3750  0

>>

>> % Compute eigenvalues and eigenvectors
[V, D] = eig(A);

% Display eigenvalues
disp('Eigenvalues:');
disp(diag(D));

% Display eigenvectors
disp('Eigenvectors:');
disp(V);
Eigenvalues:
    3.9007
    0.6054
   -0.2482
   -1.2056
   -1.0072
   -0.8503
   -0.5699
   -0.6250
    
```





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The table below shows the absolute value (λ) of eigen values and Ranking

Factors	Absolute value of λ	Ranking
C ₁ Fear	3.9007	1
C ₂ No Career and Job	0.6054	6
C ₃ Lack of Awareness	0.2482	8
C ₄ - Hardness	1.2056	2
C ₅ - Lack of Interest	1.0072	3
C ₆ - Lack of Math Ability	0.8503	4
C ₇ - Lack of Finance	0.5699	7
C ₈ -Lack of Understanding	0.6250	5

Table 3 : Ranking based on absolute value of λ

From the above table the absolute value of (λ) for Fear holds the first place. From this we can say the factor fear dominates the other factors. In summary, the cognitive matrix, defuzzified matrix, and eigenvalues offer significant insights into the intricate relationships and preferences concerning the barriers affecting students' inclination towards studying science. These results serve as a foundational basis for further analysis and interpretation, enabling the extraction of actionable insights crucial for informed decision-making in educational strategies and interventions aimed at enhancing science education.

CONCLUSION

This study identifies the main obstacles impacting students' inclination to pursue science education. A number of important elements were identified, including fear, hardness, a lack of understanding and math ability; other aspects were awareness, financial limitations, and job potential. For students to become more engaged in and involved in science education, these hurdles must be overcome with focused interventions. Educational institutions may foster a more favourable atmosphere that inspires students to pursue science education and jobs by helping, enhancing comprehension, and increasing awareness. This will ultimately lead to a more scientifically literate and active society.

SUGGESTION

- Experiences and bridge the gap between theoretical learning and practical application Dynamic Teaching Strategies: To make science classes enjoyable and engaging, use interactive and dynamic methods of education.
- Practice-oriented Uses: Include examples and applications from everyday life to show how scientific ideas are applicable in real-world situations.
- Mentorship Programs: Set up mentorship programs to offer students direction and an understanding of the opportunities in the scientific community.
- Positive Learning Environment: Reduce the fear and anxiety related to studying science by creating a welcoming and encouraging learning environment.
- Extracurricular Activities: Promote involvement in science-related extracurricular activities to foster a comprehensive understanding of the subject outside of the classroom.
- Practical Exposure: Give students hands-on experience and a peek into possible professions in science by establishing collaborations with firms and industries to provide them with practical exposure.
- Career aid Programs: Put in place career aid programs to help students with their financial worries and doubts while providing them with insightful information about the real-world implications of choosing professions in science.

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A Review on Common Street Food Borne Diseases and Bacterial Pathogens: Diversity and their Pathogenesis

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ABSTRACT

Due to the rise in many disease-causing microbes, it has become not so possible to immediately know of contamination or to rectify the causatives of the contamination of food stuffs. To be able to provide food of good quality without any adulteration is a huge deal when it comes to certain fast-food outlets. The review highlights the various organisms that are capable of causing common foodborne diseases and their pathogenesis. With the knowledge given about the mechanism of infection, it is possible to overcome the obstacles of hygiene with proper awareness given to the vendors. It is indispensable to know the exact methods with which street foods are prepared, which can provide crucial information regarding the potential threat a malpractice can bring to consumers.

Keywords: Street food, Foodborne diseases, Food quality, Foodborne pathogens, and Pathogen

INTRODUCTION

Food is indispensable to living beings, depending upon the requirement of living beings, various sorts of foods are consumed. In this rapidly developing world people have been accustomed to resorting to methods that would make their life easier; street foods are a part of the morning routine of people who seek easier means to satiate themselves. Consumables that are readily produced out in the open for immediate or later consumption are known as "street-vended foods" [1]. Street foods are a cheaper alternative to sophisticated meals and are convenient in providing satiation, where quantity is more, and the price is less. It has been stated that 74% of nations' substantial portion of the urban food supply came from meals sold on the streets [2]. The street vended foods involve foods ranging from fruits, vegetables to meat; it also includes frozen dishes. However, this costs health, since it has been proven that

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these foods are known to carry a lot of microbes due to the nature in which the food is prepared. It also comes down to the hygiene of people who are involved in vending these edible products, poor hygiene practices like unwashed hands and clothes are responsible for the transmission of pathogenic microorganisms to the food items during preparation. Hence the rise of foodborne illness is seen in such a scenario. The statistics involving foodborne illness' effect revolve around medium to lower income class people and developing countries, however it is not only limited to developing nations but also the developed nations lacking proper methods to control the contamination of foods with toxins, chemicals, and microbes. Such a case involves the report on the effects of raw milk consumption by people in England and Wales. It was reported that since 2014, seven *Escherichia coli* outbreaks were reported [3]. In this review, awareness about eating such foods' consequence is studied by microbiological analysis of the street-vended foods. Several parameters are described by WHO to control such contamination, since contamination of foods can occur at any stage, precautions must be taken to prevent drastic consequences.

CAUSES OF FOODBORNE DISEASES

Due to the risks that might be introduced to the food, which is to be prepared and processed, unprocessed ingredients are crucial to assess the safety of street-vended food. The kind and degree of adulteration of ingredients used in the producing street food will be different to that of other food service-related enterprises. The biggest variations will be seen when vendors buy cheaper, lower-grade raw materials from suppliers, as a result, the raw material is already at a higher chance to get contaminated further and might be already contaminated. Hence, raw materials should be purchased from reputable and well-known sources rather than from unreliable traders. Prior to purchase, raw materials ought to be screened for potential physical hazards and significant chemical contamination, however, it should be highlighted that chemical contamination is seldom detectable without laboratory investigation. Raw materials that are obviously physically dangerous should be avoided, or the dangers should be eliminated. For vendors of street food, managing chemical risks in raw ingredients is sometimes quite challenging [2]. A vital ingredient in many street food businesses is water. Due to its wide use, chances are that it could include harmful chemical, biological, or physical contaminants. Water is used in both liquid and solid forms for the preparation of drinks and foods. Due to the supply of water being unpredictable in certain localities there is a higher degree of the water being unclean, it has been reported that street vendors are often reluctant in washing their utensils due to such reasons. The production and sales units should, as far as is practical, have access to their own potable water supplies. Food and drinks should not be kept in the same container that is used to keep ice that is meant for consumption [2]. A neglect to clean and sterilize surfaces adequately may be caused by using unhygienic materials and poor material maintenance. For instance, to avoid the buildup of dust and other objects, bowls and plates should be placed upside down. Notably when meals are acidic, utensils should be constructed of materials that do not discharge poisonous or dangerous substances (copper, lead, cadmium, etc.) into food and beverages. Similarly, to this, chopping boards should be made and kept in good condition to lessen the possibility of physical and biological dangers contaminating food. In the series of procedures that foods go through before being sold and consumed, preparation and processing play a crucial role in establishing the safety of the product. People involved in the food preparation have a crucial responsibility to make sure that the prepared food is of good quality and free of contamination prior to sale. Food handlers should be instructed, prompted, or closely monitored to immediately cease operations if they have any sort of health issues like fever, sore throat, diarrhea and even discharges from the nose, eyes, or ears, or obviously infected skin lesions due to other health concerns. This hygiene procedure should get special consideration before handling ready-to-eat items. Vendors must adhere to cleaning methods that guarantee the cleanliness of the stall unit, its equipment, and its utensils. Vendors should be informed about the proper procedures and urged to adopt an appropriate cleaning and sanitizing program when sanitizing is necessary to control dangers. These parameters must be considered to ensure foods of good quality, but on the other hand, street vendors fail to meet these requirements. Hence the prevalence of food-borne illness is seen in food items that are exposed to such ill-treatment. In this review various microorganisms that are prevalent in such contaminated food items will be seen and their drastic effects are also discussed.



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In terms of nutrition, food is a constant requirement for human life. Unwanted microbes, on the other hand, may contaminate food items, food processing settings, or manufacturing environments, increasing the risk for food-borne [4]. Such diseases have the ability to pose a serious threat to humans, sometimes resulting in mortality. Food-borne microbes, which mostly impact animal products that have been contaminated by vegetative pathogens or their toxins, are important pathogens that affect food safety and result in human illnesses all over the world. Most of these bacteria are important zoonotic agents that have a significant impact on the economy and public health [5]. The primary food sources of zoonotic bacteria for humans include meat, dairy products, and eggs. The most common bacteria origin pathogens that cause food-borne disease and mortality worldwide are *S. aureus*, *Salmonella* species and *E. coli* [5]. Ingestion of water and a range of foods contaminated with pathogenic organisms (bacteria, viruses, parasites, and fungi), as well as their toxins and compounds, leads to food poisoning syndrome (Ingestion of water and a range of foods contaminated with pathogenic organisms) [6].

BOTULISM

Clostridium botulin produces an exo neurotoxin, which has systemic effects and causes the neuroparalytic condition known as botulism. The toxin is also occasionally produced by other *Clostridium* species, including *Clostridium butyricum* and *Clostridium barati*. This disease is known for causing flaccid paralysis. Botulinum neurotoxin is a 150kDa protein where it enters the bloodstream depending upon the type of exposure, in the bloodstream it travels and binds presynaptic nerve terminals of the voluntary motor and autonomic Neuromuscular junctions then it inhibits muscular contraction and prevents presynaptic Acetylcholine release, resulting in flaccid paralysis [7]. Due to its tremendous potency and fatality, botulinum neurotoxin is regarded as the most lethal toxin. Its lethal dosage ranges from 1 to 3 ng of toxin per kilogram of body mass. Botulism can be acquired by eating food that has been poorly preserved, receiving an iatrogenic infection, or being exposed to the toxin during bioterrorism. It can also be contracted by the systemic release of the toxin in vivo, as in the cases of newborns and wound botulism. According to serologic specificity and other neurotoxins, seven distinct strains of the organisms (A-G) are categorized. Animals commonly contract type C and D botulism and very rarely type A and B. All strains that produce toxins have been assigned to one of four groups: I, II, III, or IV. Proteolytics are in Group I, non-proteolytics are in Group II, and serological type G is in Group IV. Group III includes type C and type D.

CLOSTRIDIUM PERFRINGEN RELATED FOOD POISONING

C. perfringen type A food poisoning, a common food-borne illness in western nations. It contains seven toxicogenic kinds (A-G), of which strains A and C are harmful to humans and is catalase and superoxide dismutase negative, it generates a wide range of poisons [8] [9]. Food poisoning can be triggered by *C. perfringens* enterotoxin (CPE), which is produced in the small intestine by *C. perfringens* spores that can germinate in meals like meat and poultry. Alpha-toxin (CPA), beta-toxin (CPB), epsilon-toxin (ETX), iota-toxin (ITX), enterotoxin (CPE), and necrotic enteritis B-like toxin (NetB), these toxins production by this pathogen are used as a classification [10]. Toxin-mediated tissue necrosis is the basis of *C. perfringens* pathophysiology. Most toxins have the ability to cause pores in cells, allowing water and solute to flood in and cause swelling and cell death. The fermentation of glucose results in the generation of histotoxic gas, which is a defining feature of *C. perfringens* [9].

STAPHYLOCOCCUS AUREUS FOOD POISONING

Only the enterotoxin-producing strains of the gram-positive bacterium *Staphylococcus aureus* can cause food poisoning. Such toxins are termed *Staphylococcus enterotoxins* (SEs). *Staphylococcus aureus* is a gram-positive bacterium, where only certain strains that produce enterotoxin can cause food poisoning. Such strains are known to produce six types of enterotoxins (SEA, SEB, SEC, SED, SEE, SEG and SEH) that have serological diversity and differ in the levels of toxicity [11]. The emetic action of SEs is a significant aspect since it causes vomiting, which is a primary symptom of Staphylococcal food poisoning. Diarrhea is also caused by some SEs but not SEC. Due to the difficulty in identifying toxins present in food other than SEA and SEE, many staphylococcal related foods poisoning is attributed to the SEA [12]. Appropriate major nutrient contents like carbon and nitrogen sources in the food can give suitable place for the bacteria to grow and this occurs mainly due to food vendors since these bacteria are known to be

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present on skin and mucous membranes of humans and that humans are major reservoir of this organism [13]. Reheating food may kill *S. aureus*, but SEs remain emetically active due to its' heat tolerance, these are also tolerant towards gastric enzymes since its activity is based upon their entry thru the intestinal epithelial cells. Once entered, they reach lamina propria and provoke mast cells to release serotonin. In turn serotonin stimulates the vagus nerve and it is involved in the production of an emetic response. It is known that SEs are predominantly found in raw milk and its products where SEC and SEA are commonly found in them.

SALMONELLOSIS

Clinical manifestations of salmonellosis range from the typical *Salmonella gastroenteritis* (diarrhea, stomach pain, and fever) to enteric fevers, including typhoid fever, which is a serious feverish systemic infection that needs immediate antibiotic treatment [14]. *Salmonella nontyphoidal* species are zoonotic pathogens, and the primary means of transmission is through animal-derived foods. Although the microbe has been discovered in other foods, poultry, pigs, and cattle, as well as related products such as meat, eggs, and milk, are most frequently recognized as dietary sources responsible for outbreaks of human salmonellosis [5]. They are known to colonize the small intestine's final section, ileum and the colon and invade the intestinal epithelium by adhering and proliferate there. Most salmonellae elicit an initial inflammatory reaction after infecting the intestine, which can result in ulceration.

KLEBSIELLA PNEUMONIAE RELATED FOOD POISONING

Klebsiella pneumoniae has been regarded as a significant food-borne pathogen since it is regularly discovered in foods such as raw vegetables, powdered newborn formula, meat, seafood, and street foods. The virulence factors that *K. pneumoniae* may express include capsules, endotoxins, siderophores, iron-scavenging systems, and adhesins. It has been shown to be crucial in the pathogenesis of the disease [15]. The capsule is a key factor engaged in at least two pathogenic processes, namely the direct inhibition of the vulnerable host response and the protection of bacteria from phagocytosis. Numerous capsule types (K), including K1, K2, K54, K57, K20, and K5, are frequently linked to the occurrence of invasive pyogenic liver abscess and septicemia [16]. Adhesins are bacterial components or cell surface elements that make it easier for bacteria to adhere to or connect to other cells on the host where they dwell or infect. Adherence is a crucial stage in the pathogenesis of bacteria or an infection that is necessary for the bacteria or infection to colonize a new host. For the prevention or treatment of bacterial infections, bacterial adhesions and adhesions are important targets. Other key components influencing an organism's pathogenicity are lipopolysaccharides and CPS. Antigens found in lipopolysaccharides, including lipid A, core, and O-polysaccharide, are necessary for bacteria to fend off complement-mediated payoff [17].

FOODBORNE PATHOGENS

Pathogens that cause illnesses when consumed foods that are contaminated with them are known as foodborne pathogens. These biological agents that can cause foodborne illnesses undergo a series of events to establish themselves in the vulnerable host to produce toxins or use their virulence factors to elicit an immune response and affect the host.

Escherichia coli

Gram-negative, non-spore-producing, rod-shaped, facultative anaerobic, and coliform bacterium belonging to the genus *Escherichia* is motile pertaining to peritrichous flagella arrangement with the exception of few strains. Typically rod-shaped, cells range in size with 1–3 μm \times 0.4–0.7 μm and 0.6–0.7 μm in volume. By employing negative staining techniques, which result in a brilliant halo over a dark background, the *E. coli* capsules may be seen clearly. They only have one or two peptidoglycan layers in their thin cell wall. On McConkey agar, these lactase fermenters create pink colonies. A particular strain of *E. coli* is known for its hemolytic activity on blood agar. It inhabits the environment, food, and lower gut of homeothermic animals. *E. coli* grows best at 37°C (98°F), however some lab strains may thrive at temperatures as high as 49°C (120.2°F). *Escherichia coli* (*E. coli*) is a gram-negative bacillus that causes a variety of diarrheal diseases, such as dysentery and traveler's diarrhea. It is commonly employed as an indicator organism for water pollution since it can exist for a very long time in feces, soil, and water. It is also classified into 200 serotypes based on its 3 antigens [18]: Somatic or cell wall antigen (o), capsular antigen (K) and

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flagellar antigen (H) Numerous different *E. coli* strains have been found, causing illnesses ranging from mild, self-limiting gastroenteritis to renal failure and septic shock. *E. coli*'s virulence makes it easier for it to overcome host defenses and acquire antibiotic resistance.

- Enterotoxigenic *Escherichia coli* (ETEC),
- Enterohemorrhagic *Escherichia coli* (EHEC), also known as Shiga toxin-producing *Escherichia coli* (STEC),
- Enteroinvasive *Escherichia coli* (EIEC),
- Enteropathogenic *Escherichia coli* (EPEC) and
- Enteroaggregative *Escherichia coli* (EAEC).

These are the causative *E. coli* subtypes [19]. One out of five subtypes of *E. coli* that cause intestinal sickness may be recognized by their O and H antigens. A repeating polysaccharide chain found in the lipopolysaccharide (LPS) outer membrane defines the O antigen, while the flagellum determines the H antigen as mentioned before. Characterization is done by isolating the targeted organism by identifying the general morphology, depending upon the medium used we can classify different strains of *E. coli*. In general, on a basic nutrient agar medium, *E. coli* form large and thick colonies that appear greyish white in color; they are also seen as opaque or translucent moist and smooth discs in the culture medium. This species gram negative, rod shaped and non-spore producing. Lactose fermenting strain can be isolated using MacConkey agar, here the lactose fermenting strain can be seen as round medium sized colonies that also appear pink in color [20]. It also has to be considered to opt for optimal conditions like salt concentration, temperature and pH, for example using the temperature 45°C will give rise for thermophilic strains. In blood agar they show beta hemolysis when they are obtained from pathological conditions [21]. It has been stated that Eosin-methylene blue agar can be used as media to differentiate gram negative bacilli and enteric bacilli [22], *E. coli* gives out a metallic sheen with a dark center, this is due to the change in the pH of the medium to acidic owing to the metachromatic property of dyes coupled with the lactose fermenting property of this bacilli [21]. The isolates obtained can be further confirmed by biochemical tests involving Indole, Methyl red, Voges-Proskauer and Citrate utilization tests. In Indole and Methyl red test the *E. coli* give out positive results. For the latter tests *E. coli* gives out negative results. Certain selective media can also help in confirmation of the isolates, like The Brilliance *E. coli* agar is used to check for the activity of the enzyme Beta-glucuronidase, a specific enzyme pertaining to this species it cleaves the glucuronide present in agar to yield purple and blue-green colonies in this agar [20].

ETEC

Marked by its characteristic to cause watery diarrhea in infants, children and even adults, is found in contaminated water and food. Their heat stable and labile toxins are key virulence factors in promoting watery diarrhea. The heat labile toxin (LT) acts by stimulating the adenylate cyclase which leads to the formation of increased intracellular cAMP- cyclic adenosine monophosphate, it also promotes increased secretion of chloride from that crypt cells of the intestine. This mechanism prevents sodium chloride from being absorbed by intestinal villi. Ultimately Watery diarrhea results from this process due to free water discharge into the intestinal lumen. On the other hand, the heat-stable toxin (ST) induces the stimulation of guanylate cyclase, leading to a rise in intracellular cyclic guanosine monophosphate (cGMP), which causes chloride to be secreted and sodium chloride absorption to be blocked, resulting in watery diarrhea.

EHEC

This Shiga-toxin producing strain is highly responsible for diarrheal outbreaks caused due to the ingestion of contaminated green leaves and fruits and even undercooked meat. The Shiga toxin 1 and 2 (stx1 and stx2 respectively) are closely related to Shiga toxin produced by *shigelladysenteriae*. Stx2 expressed by this strain is known to cause bloody diarrhea. The Stxs are a class of bacterial AB protein toxins consisting of one A subunit and five identical B subunits that can target eukaryotic ribosomes to impair protein synthesis. The B pentamer binds to the endothelial cell receptor, glycosphingolipid Gb3, whereas the A subunit inhibits protein production. Inhibiting protein synthesis causes the death of enterocyte cells, which is followed by inflammatory colitis. Intimin, the key adhesin of EHEC is encoded by the genome, and EHEC/STEC has a plasmid (pO157) that expresses the pore-forming toxin known as EHEC-hemolysin [23] [24].



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Just like EHEC the Enterotoxins produced by EIEC cause diarrheal secretion. Inflammatory colitis is the outcome of further colonization, invasion, replication, and cell-to-cell dissemination. Such toxins invade and kill the colonic epithelium, causing illness that is initially characterized by watery diarrhea. Inv plasmid, chromosome and plnV genes are the virulence factors involved in causing the disruption of colonic epithelium.

EPEC

The aftermath of contracting this strain is watery diarrhea in children and infants due to the virulent factor called Bundle-forming pilus (BFP) which renders it capable to form an attachment to enterocyte of the small intestine, the plasmid "pEAF" is responsible for encoding the BFP. After its attachment, Intimin an outer membrane protein colonization factor helps in further adherence, within the Locus of Enterocyte Effacement chromosomal island, the attaching and effacing (eae) gene can be found where the intimin is encoded on [25].

EAEC

It is known to cause traveler's diarrhea, Intestinal epithelial adhesion, mucus production stimulation, biofilm development, cytotoxic damage, and mucosal inflammation are all various aspects of pathogenesis. Many virulence factors are said to be involved in these processes. Which includes the Aggregative Adherence Fimbriae (AAF) and its variants (AAF I to AAF V). The virulence plasmid containing AggR (transcriptional regulator) and Dispersin (AAF dispersal contributor) called pAA is where the AAF is encoded on [26]. Several studies have shown the other virulence factors like Enteroaggregative *E. coli* heat-stable enterotoxin-1 (EAST-1), haemolysin E (HlyE) and cytotoxins Pet [27].

Staphylococcus aureus

Gram-positive, spherical in shape, often found in clusters. They are non-motile, non-flagellated, non-capsulated and non-sporing. The cells' diameter ranges from 0.5 to 1.0 μm . On a nutrient-rich agar medium, *S. aureus* develops significant yellow or white colonies. It is aerobic, at times a facultative anaerobe. It is catalase positive and oxidase negative. The nose, throat, hair, skin, and mucous membranes of healthy individuals are *S. aureus*'s natural habitats. Enterotoxins are produced by toxic *s. aureus* strains, when ingested foods contaminated with such strains in the number higher than 10⁴ per g of food, resulting in staphylococcal food poisoning. Serologically different enterotoxins A, B, C1, C2, D, and E are produced by enterotoxigenic *S. aureus* strains. Enterotoxins can tolerate heating at 100°C for 30 minutes. SEs, hemolysins, leukotoxins, exfoliative toxins, and toxic shock syndrome toxin-1 are the most important secreted toxins [28]. The bacterium frequently produces four different forms of hemolysins (alpha, beta, gamma, and delta), due to this it is hemolytic in blood agar. The organism can thrive on mannitol-salt agar medium with 7.5% sodium chloride because it is salt-tolerant. One of the most prevalent bacterial infections in humans is caused by *S. aureus* which includes bacteremia, urinary tract infections, toxic shock syndrome, and gastroenteritis.

There are five phases during a *S. aureus* infection. These include colonization, local infection, systemic spread and/or sepsis, metastatic infections, and toxinosis. The species is known to pertain to the anterior nares during the carrier stage for weeks or months without producing infections; The bacterium can enter the bloodstream and spread throughout the body to various organs, leading to sepsis. Endocarditis, osteomyelitis, renal carbuncles, septic arthritis, and epidural abscesses can all be caused by this hematogenous spread. Specific symptoms can develop because of *S. aureus* extracellular toxins without a bloodstream infection, these include foot-borne gastroenteritis, scalded skin syndrome, and toxic shock syndrome [29]. *Staphylococcal enterotoxins* (SEs) are one of the most frequent causes of food poisoning. During growth, *S. aureus* produces SEs along with a variety of other virulent components. The bacterium has the ability to spread multiple infectious illnesses, such as toxic shock syndrome (TSS), in addition to food intoxication. Exopolysaccharides, surface-associated protein adhesins, immunological modulators, and exoproteins, along with a range of toxins, are among the staphylococcal virulence factors [30]. As previously mentioned, the important toxins secreted include SEs, hemolysins, exfoliative toxins, leukotoxins, toxic shock syndrome toxins (TSST-1), among these 25 SEs have been identified [31]. There is also another class of SEs, called the SEIs (enterotoxin-like proteins). The emetic action of SEs is a noteworthy characteristic. It causes vomiting, which is a



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primary symptom of SFP. However, SEs do not always produce diarrhea. SEG-SEIZ are referred to as "new enterotoxins," whilst SEA-SEE are referred to as "classical enterotoxins". The emetic activity of classical enterotoxins was described in the paper of Bergdoll M.S et al., 1988 [32]; whereas the emetic activity of new toxins has not been well established yet. The enterotoxins whose emetic potential has not been confirmed in primate models have been designated as SEIs. To be precise SEs are divided into categories based on their nucleotide and amino acid sequences, example: SEA group involves the SEs, SEA, SED, SEE, SEIU, SEH, SEN, SEO, SEP, SES, then there's SEB group involving SEB, SEC, SER,SEIU, SEIW. Food poisoning due to this organism is mostly associated with SEA since detecting the enterotoxins from SEA to SEE is easier using appropriate test kits. It is also possible that all the toxin varieties can act synergistically. The SEs get access to the lamina propria thru mucus producing epithelial or goblet cells of the small intestine, SEs then stimulate the release of serotonin and histamine from the mast cells, this in-turn evokes an emetic response in the host by acting on the vagus nerve.

Clostridium perfringens

They are gram-positive, anaerobic, fermentative, and spore-forming. The most well-known toxin-producing species are *Clostridium perfringens* and *Clostridium botulinum*, which can result in mild to deadly food poisoning. They are motile, obligatory anaerobes with varying tolerance to oxygen and catalase & oxidase negative. The organisms concerned are widespread and are found in the intestines of animals and humans and in the soil, where they can thrive. Different species require growing environments; some are thermophilic, while others are mesophilic [33]. The optimum temperature was found to be approximately 45°C and the generation time is less than 10 minutes, described by Labbe R., et al, 2014 [34]. The species *clostridium perfringens* is well known to cause illnesses infections that range in variety of severity, starting from diarrhea to myonecrosis; this is possible due to its toxins and capability or producing stress tolerant spores. It produces six major toxins, and they are described in the review by Yao P. Y et al., 2023 [9]; hence its classification is based on the major toxin/toxins produced by the different classes of *C.perfringens*. The six major toxins are Alpha toxin (CPA), Beta toxin (CPB), Epsilon-toxin (ETX), Iota toxin (ITX), Enterotoxin (CPE) and Necrotic enteritis B- like toxin (NetB). Class A produces CPA alone, B is involved in the production of CPA, CPB and ETX, C produces CPA, CPB and CPE (positive/negative), D produces CPA, ETX and CPE, E is involved in producing CPA, ITX and CPE as well, then F produces CPA and CPE and finally the class G produces CPA and NetB. Out of this the type A is known to be the cause for almost all *C. perfringens* related food poisoning.

CPA

It is associated with breaking down the phospholipid called the phosphatidylcholine & the sphingolipid called sphingomyelin of the nerve cells, these are components of cell membrane. This results in stimulation of neutrophils and activates arachidonic acid metabolism further leading to aggregation of platelets and vasoconstriction. Since the 1930's the role of these toxins has been researched and it has been established in the paper of MacFarlane, Knight and co workers in 1941 [35] that the alpha toxin is a phospholipase, an enzyme.

CPB

It is pore forming and it binds to endothelial cells possessing neurotoxic properties. Theoret J R et al in 2015 [36] have stated that this beta toxin binds to vascular endothelial cells and causes vascular necrosis, hypoxic necrosis as well as hemorrhage [37].

CPE

This toxin binds to the claudin receptors on the surface of the cell, leading to the formation of hexamer, which causes an influx of calcium ions. This ultimately leads to activation of calpain, it has been that Calpain, a calcium activated protease usually exists as an inactive pro enzyme in cytosol [38], when there is an influx of calcium at intracellular level, the calpain is activated then it proceeds to cleave cytoplasmic & nuclear substrates which leads to cell death.





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Klebsiella pneumoniae

They are Gram negative, non-motile, facultative anaerobes and they thrive at 37°C. They produce mucoidal colonies on media that are rich in carbohydrates. They are straight rods approximately 0.3 to 1.8 µm. They are oxidase negative, Voges-Proskauer and catalase positive, certain subspecies of *K. pneumoniae* are Voges-Proskauer negative, E.g: *K.pneumoniae subsp. ozaenae* & *K.pneumoniae subsp. rhinoscleromatis* [39]. Many of the strains are capable of hydrolysing urea and reducing nitrates without hydrogen sulphide gas evolution. *K.pneumoniae* possesses polysaccharide capsule, this determines its pathogenicity. The capsule is made up of complex acidic polysaccharides, it protects the bacterium from host's defenses like phagocytosis and proteins that are bactericidal, the capsular types include K1, K2 K5, K54, K57 and K20. During the infection, the frimbrial and non frimbrial adhesions help in adherence to the host's cell [40]. Along with this they possess additional virulence factors like adhesins, siderophores (enterobactin), endotoxins, and scavenge systems. It produces two major fimbriae, type 1 & 3, the type 1 is thin, rigid and adhesive found on the surface of family- *enterobacteriaceae*. Type 1 fimbriae's adhesive properties are due to FimH adhesin recognizing glycoproteins that contain mannose.

Salmonella enterica

They are gram negative *bacilli*, facultative anaerobes with flagella. Some species like *Salmonella Galinarum* and *Pullorum* are non-flagellated and non-motile [41]. The range is from 0.2 - 1.5 µm x 2 - 5µm in size. They are characterized by the presence of antigens like O, H and Vi. They are non-fastidious and heat sensitive (> 70°C), their optimal temperature requirement is 32 - 35°C and they can thrive at temperatures between 5- 47°C. They can grow at pH ranging from 4 - 9 and the optimum being 6.5 - 7.5. This pathogenic species contains three main antigenic components namely: Flagellar antigen denoted as H, Somatic antigen occurring on surface of outer membrane, it is determined by sugar sequences on cell surface, and it denoted as O and antigen that is specific to serotypes denoted as Vi. The lipopolysaccharide covering is also considered as an antigen, it can function as an endotoxin. Such an endotoxin exists as a complex of three components namely O-polysaccharide covering, middle portion and inner lipid A covering.

CONCLUSION

Antibiotics are substances that inhibit growth and kill the pathogens that cause harm in several ways. Over the years, due to the misuse and overuse of antibiotics, these pathogens have been showing resistance towards the existing antibiotics due to the mutations in their genes and the emergence of resistance genes in their chromosomes and plasmids as well. Antibiotics have several mechanisms to destroy the pathogens, it includes cell wall/membrane disruption/damaging, inhibition of protein or nucleic acid synthesis, interruption of transcriptional/translational processes. The way in which the microbes are resistant varies from species to species, one such mechanism is the production of enzymes that inactivate the antibiotics such as the Beta-lactamase enzyme by Gram positive/negative bacteria. This acts on the amide bond of the beta-lactam ring therefore it inactivates the Beta-lactam ring containing antibiotics hence rendering it useless against such microbes. Likewise, *Klebsiella pneumoniae* has also shown resistance towards a variety of antibiotics, in a study done by Shuhong Zhang *et al* in 2018 [42] it has shown resistance to piperacillin, cephalothin, streptomycin, ampicillin and as well as tetracycline. Carbapenemase producing microbes are also a threat, they are mostly found in the family *enterobacteriaceae*, *Klebsiella pneumoniae* has the ability to produce this enzyme along with another gram-negative organism like the *Pseudomonas aeruginosa*. In certain *E. coli* strains that were found to be resistant had resistance genes that were capable of producing extended-spectrum beta lactamases that act against monobactams, cephalosporins and penicillin [43]. *E.coli* has also seen to be resistant to gentamicin, ceftriaxone and chloramphenicol [44] and its strains were also seen to be resistant to many more antibiotics, this is alarming due to the fact that foods contaminated with multidrug resistant microbes can mean that the illness caused by it to be very challenging and tough to cure, making food poisoning a life threatening condition. Similarly, *Salmonella species* are also found to be resistant to common antibiotics like penicillin, amoxicillin and gentamicin, *staphylococcus aureus* is also found to bear the same resistance. It can be interpreted that foods are potential carriers of pathogens when they are produced with no proper care. When it is contaminated, it can be understood that various



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toxins from these pathogens can cause severe harm to human beings. Apart from illnesses it can also act as a place that can spread the antibiotic resistant variants of these pathogens. Hence there is a dire need for proper awareness regarding food safety before it turns into a major threat. There is a dire need for current research to be involved in the prevention/control of food borne pathogens. Food preservatives help in the storage of these foods in the longer run, applicable to packed ones but the street foods have no alternatives, highly dependent on the food vendors' hygiene practice.

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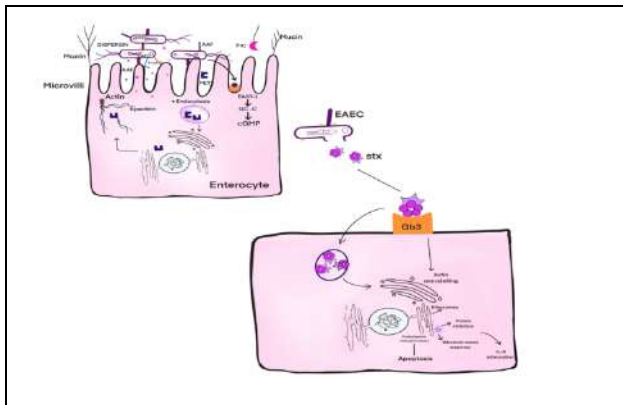


Figure 1: EPEC Infection causing mechanism.
 In figure 1, it can be seen that the AAF that are extended by the dispersin lying on the surface of the bacterial cell helps in the attachment to the host cell, Adhesins such as Tia and Hra $\frac{1}{2}$ involve in further attachment processes. Pic is involved in digesting mucin on host cells. Pet is endocytosed and then undergoes retrograde trafficking to cleave spectrin, further disrupting the actin cytoskeleton

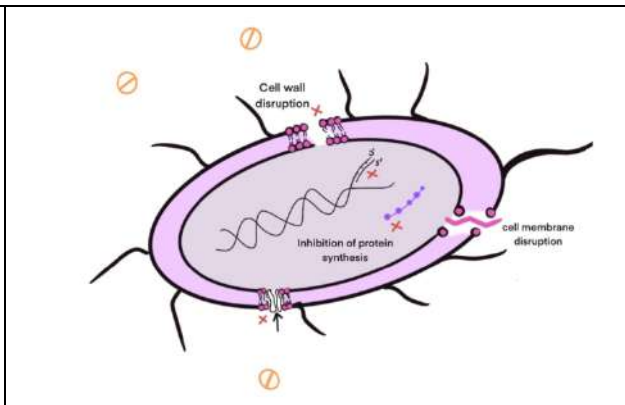


Figure 2: Antibiotic action.





Assessment of the Physico-Chemical, and Biological Profile of the Two Water Bodies in Harapanahalli and Arasikere of Karnataka

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ABSTRACT

The importance of water in lakes extends far beyond its role as a mere liquid; it regulates temperature, supports aquatic life, and facilitates essential processes like nutrient cycling. The study presents a thorough investigation into the physical, chemical, and biological parameters of two lakes in Karnataka, India: Ayyanakeri Lake, and Sannakere Lake, shedding light on their overall health and pollution status. The analysis of water quality parameters reveals diverse conditions and varying levels of pollution in these freshwater ecosystems. While, some parameters meet acceptable standards, such as pH and fecal coliform counts, others indicate potential environmental concerns, including elevated levels of turbidity, total dissolved solids, and chemical oxygen demand. Additionally, the objectionable odors and disagreeable tastes further underscores the impact of pollution sources on sensory aspects of the water. The findings highlight the distinct characteristics of heavy metal presence in Ayyayanakere and Sannakere Lakes, indicating potential mineral enrichment and contamination sources, respectively. Fecal coliform counts, unveil fluctuating contamination levels, necessitating continual monitoring and management efforts. The research underscores the urgency of implementing remedial measures to enhance water quality and preserve the ecological balance of these lakes. Sustained vigilance and proactive interventions are imperative to mitigate pollution risks and ensure the long-term sustainability of freshwater reservoirs in the region.





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Keywords: Chemical speciation, Contaminant levels, Ayyanakeri and Sannakere Lakes, Physico-chemical analysis, Heavy metals, MPN test.

INTRODUCTION

Water bodies are important resources used for inland fisheries and recognition of various fish fauna, which offers great prospects for the improvement and sustainable management of water bodies (Krishna and Piska, 2006). Water is a renewable natural resource and the basis of life. Lentic water is used for drinking and domestic purposes. Physico-chemical factors are developed based on scientific data on the impact of pollutants on specific water uses (Rashmi et al., 2013; Thirumala and Kiran, 2018). Rapid development, population growth in metropolitan areas and urbanization in rural areas are increasing ecosystem pollution in complex ways. The most affected are water bodies that are severely affected by the addition of foreign bodies such as flora and fauna, domestic and industrial wastewater. Solid waste dumping and unplanned interventions also increase the disturbance. The deterioration of water quality significantly limits its availability for human consumption and marine life. Therefore, consistent and regular monitoring of water quality is essential to take appropriate preventive and medical measures. The BOD and bacterial characteristics of a water body indicate the type of pollution and the water quality. Water pollution has become a challenging issue today as all water resources are under threat due to spontaneous urbanization and industrialization (Singh et al., 2002). It is known that humans, animals, and plants all face various problems arising from different types of environmental pollution (Petak, 1980; Pushkar Lal Dangi et al., 2017). Unlike the misuse of inorganic waste, organic waste is easy to dispose of as it is biodegradable. In fact, nature has some very effective mechanisms to purify itself of such waste over time through biological transformation and recycling. The Stockholm Conference on Human Climate (Jones, 1972) proposed regulating crop residues and animal waste and recycling them as compost. Of course, a heterogeneous mixture of bacteria, plants and other parasites plays an important role in the biological decomposition of organic waste. However, if this is not done efficiently, general health can be significantly impaired, as many types of microorganisms are involved in the exploitation of human and animal sources. Up to 10,000,000 bacteria can be found in one gram of human waste (Hultan, 1981; Pushkar Lal Dangi et al., 2017). Furthermore, organic waste is rich in biologically important nutrients and can alter the environmental conditions of receiving water bodies. As a result, disposal of raw organic waste can accelerate eutrophication. Recognizing the critical importance of lake water quality and the pressing issue of pollution, the main aim of the study was to comprehensively assess the pollution status of lakes in the Arasikere, and Harapanahalli regions of Karnataka. This involved identifying lakes where there is limited information available regarding pollution levels or scientific studies, thus addressing gaps in environmental monitoring and management efforts. The survey encompassed a range of scientific methodologies and interdisciplinary approaches to assess water quality, pollution sources, and ecological health of the two water bodies.

MATERIALS AND METHODS

Study area

A comprehensive field survey was recently conducted to investigate the key parameters of lakes in two locations: Harapanahalli and Arasikere. Located within Vijayanagar district, the Ayyanakeri Lake in Harapanahalli, Karnataka, plays a crucial role in shaping the ecological and socio-economic dynamics of the area. Positioned at 14.787° N latitude and 75.9818° E longitude, this lake is not only a picturesque feature of the landscape but also a lifeline for nearby communities. Serving as a primary water source, it sustains a rich diversity of plant and animal life, making it an essential ecosystem within the region [Figure 2]. Lastly SannaKere, found in Arasikere and marked by coordinates latitude 14.673° N and 76.074° E longitude, holds significance as a prominent lake within the area. The water in the lake was not suitable for consumption due to the direct discharge of wastes from Slaughter houses located around the lake and sewage effluents of the village [Figure 3].



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Sampling and Laboratory Analysis

Samples of water from all the five lakes were methodically collected in 5 liter polythene bottles from the field sites and ferried to the laboratory for detailed analysis. These samples were meticulously handled to ensure the preservation of their integrity and to prevent any contamination during transit. In the laboratory, comprehensive assessment of various physico- chemical and biological parameters was performed to assess the quality and composition of the water.

Physical parameters

To determine different physical properties of water such as temperature, pH, turbidity, conductivity, and dissolved oxygen concentration the following procedure were followed

Fecal Coliform testing [MPN] Method

The procedure for Fecal Coliform testing, according to the standard procedure, involved utilizing the Most Probable Number method to quantify fecal coliform bacteria in water samples. The process began with serial dilution of the water sample to generate a range of concentrations suitable for the MPN test. Subsequently, aliquots of these diluted samples were inoculated into multiple tubes or wells containing selective culture media like MacConkey broth or Lauryl tryptose broth. The inoculated media were then incubated at the prescribed temperature [typically 37°C] for 24 to 48 hrs to facilitate bacterial growth. Following the incubation period, the tubes or wells were examined for bacterial growth, indicated by turbidity or gas production. Confirmation tests, such as the indole test or methyl red test, were conducted on samples showing positive growth to confirm the presence of fecal coliform bacteria. Finally, the MPN was calculated based on the number of positive tubes or wells at each dilution level, referencing the MPN table provided in the standard to determine the Most Probable Number of fecal coliform bacteria per 100 milliliters of the original water sample.

RESULTS

Ayyanakeri Lake Water

Physically, the color of the water is measured at 198, which is within the acceptable range according to IS – 22.96 “C”. Temperature of the water was 28°C, the odor is objectionable, and the taste is disagreeable, indicating potential contamination sources affecting the sensory aspects of the water. Chemically, the pH level is recorded at 7.70, falling within the acceptable range of 6.5-8.5. However, the electrical conductivity is notably high at 2500 $\mu\text{s}/\text{cm}$, suggesting a significant presence of dissolved ions. TDS are measured at 1452 mg/L, exceeding the recommended range of 50-250 mg/L, indicating elevated mineral content. Calcium, Magnesium, Sulfate, and Chloride concentrations are within measurable ranges, but some exceed standard limits. For instance, sulfate and chloride levels are above the recommended standards of 250 mg/L. Nitrate levels are also slightly elevated at 3.0 mg/L, although still below the permissible limit of <10 mg/L. Biologically, the total coliform count was 18 MPN/50ml while these counts suggest a moderate level of fecal contamination, they still fall within acceptable limits. Overall, the data indicates a mixed picture of water quality in Ayyanakeri Lake, with some parameters meeting acceptable standards while some express concerns regarding potential pollution sources. Continued monitoring and management efforts are necessary to address water quality issues, ensuring the ecological integrity and usability of the lake for various purposes [Table 1].

Sannakere Lake Water

Physically, the color of the water was 192, and the temperature was recorded at 24.7°C, which falls within the typical range for surface water bodies. However, the odor is objectionable, and the taste is disagreeable, indicating potential contamination affecting sensory aspects of the water. Chemically, the pH level is slightly alkaline at 7.66, within the acceptable range of 6.5-8.5. Electrical conductivity is notably high at 2870 $\mu\text{s}/\text{cm}$, indicating a significant presence of dissolved ions. Turbidity is relatively low at 6.6 NTU, suggesting clarity in the water. TSS are measured at 80 mg/L, which is below the standard limit of 100 mg/L, indicating relatively low levels of particulate matter. However, TDS are recorded at 1683 mg/L, exceeding the recommended range of 50-250 mg/L, suggesting elevated mineral content.



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Biologically, the fecal coliform count was 78 MPN/100ml, which is below the permissible limit of 100 MPN/100ml, indicating relatively low levels of fecal contamination. This suggests that the water may be suitable for recreational activities, but continued monitoring is essential to guarantee adherence to water quality regulations. Overall, while some parameters meet acceptable standards, others raise concerns regarding potential pollution sources and environmental degradation. Continued monitoring and management efforts are essential to address water quality issues in Sannakere Lake, safeguarding its ecological integrity and usability for various purposes [Table 5].

DISCUSSION

Comparing the color and temperature of Ayyanakeri Lake, and Sannakere Lake, distinct variations are evident, offering insights into the unique characteristics of each water body. Conversely, Sannakere Lake records a slightly lower temperature of 24.7°C, implying cooler conditions. Our findings align with observations of water color in Bengaluru City lakes, which generally adhere to prescribed limits, signifying minimal pollution, despite seasonal fluctuations affecting other physicochemical parameters (Carrea et al.,2023). Similarly, studies on Puliyanthangal Lake note variations in water appearance from turbid to clear, influenced by the influx of tannery effluents and domestic waste (Chatterjee and Ganesh,2020). In Maharashtra's Malijunga Lake, water temperature displays seasonal variability, indicating the influence of climatic changes on lake water temperature (Maheshwari and Sivachandrabose,2023). Ayyanakeri Lake, and Sannakere Lake exhibit objectionable odor and disagreeable taste, suggesting potential contamination sources affecting water quality. Our findings resonate with studies on Lake Goverdhan Sagar and Puliyanthangal Lake, which report similar issues with odor and color, indicating potential water quality challenges (Maheshwari and Sivachandrabose,2023; Patida,2022; Kumar et al.,2020). The chemical parameters of lake water, including pH, EC, TDS, and Turbidity, have been extensively investigated across various lakes, reflecting their diverse environmental conditions and anthropogenic influences (Turunen and Aroviita,2024). When comparing the pH, electrical conductivity, TDS, and turbidity of Ayyanakeri Lake, and Sannakere Lake with findings from other studies, several noteworthy comparisons emerge. Our results show that Madiwala Lake exhibits a pH of 7.54, similar to findings from Pulicat Lake, which recorded a pH of 8.17, indicating slightly alkaline conditions (Sumithra et al.,2022; Kumar,2023). Additionally, where most physicochemical parameters, including pH, were within WHO limits (Suresha et al.,2023). Electrical conductivity in Ayyanakeri Lake [2500 $\mu\text{s}/\text{cm}$] suggests varying mineral content, resembling observations in Medchal Lake, where water was deemed suitable for drinking based on permissible EC levels (Randrianiaina et al.,2019). Moreover, our study underscores the importance of continued monitoring and management efforts to ensure the sustainability of freshwater resources, echoing the sentiments expressed in various studies emphasizing the significance of assessing physicochemical parameters for water quality and health implications (Tigga and Pandey,2023; Santhi et al.,2023).

The chemical parameters of lake water, specifically sulfate, chloride, nitrate, and fluoride, vary across different studies, reflecting the diverse ecological statuses and anthropogenic impacts on these water bodies. These variations highlight the complex interplay between natural processes and human activities in shaping the chemical composition of lake waters. Comparing sulfate, chloride, nitrate, and fluoride levels across Ayyanakeri Lake, and Sannakere Lake reveals significant variations in these chemical parameters, indicating diverse pollution sources and ecological conditions. Ayyanakeri Lake also exhibits elevated levels of sulfate and chloride, suggesting increased mineralization and potential contamination. Sannakere Lake's data regarding these parameters is not provided. Fluoride levels vary across the lakes, Ayyanakeri Lake's fluoride content is not specified. These variations highlight the diverse chemical compositions and pollution sources affecting the lakes, emphasizing the need for targeted management strategies to mitigate contamination risks and safeguard water quality. Continued monitoring and remedial actions are essential to ensure the ecological integrity and usability of these freshwater ecosystems. The acceptable chloride and fluoride levels in Lake Badovci contribute to its moderate ecological status (Chatterjee and Lataye,2020), contrasting with potential pollution impacts observed in Puliyanthangal Lake (Maheshwari and Sivachandrabose,2023). While specific data on sulfate, chloride, nitrate, and fluoride were not provided for Lake Pomacochas, (Leiva Tafur et al.,2022),our study's focus on these parameters adds depth to understanding water quality issues in different ecosystems. Lake



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GoverdhanSagar's chloride and fluoride levels were below permissible limits, consistent with our findings, though sulfate and nitrate concentrations were not specified (Patida,2022). The chemical parameters of lake water, such as DO, [COD], and [BOD, are crucial indicators of water quality and its suitability for various uses. When comparing DO levels across Ayyanakeri Lake, and Sannakere Lake, significant variations in water quality indicators are evident. In contrast, various studies have shown a range of DO levels supporting aquatic life, such as 5.4 mg/l (Santhi et al.,2023)and 5.65 ± 0.13 to 8.99 ± 0.19 mg/l (Arik and Muliadiasa,2023). Urban and rural lakes in Bangalore, including the cleanest one with a DO of 3.6 mg/L [Patida, 2022], exhibited lower DO levels, suggesting some degree of pollution. Similarly, DO levels in Lake GoverdhanSagar ranged from 5.4 ppm (Santhi et al.,2023)to 7.69 mg/L in Lake Hayq (Gobeze et al.,2023). These variations highlight differing levels of aeration and biological activity within these aquatic environments. When comparing COD across Ayyanakeri Lake, and Sannakere Lake, significant variations in water quality indicators are observed. Madiwala Lake exhibits a relatively high COD value of 309.5 mg/L, suggesting a notable organic pollution burden and the presence of oxygen-consuming substances. Lake GoverdhanSagar, on the other hand, showed a COD value of 45.88 ppm (Suresha et al.,2023;Gobeze et al.,2023) , reflecting a comparable organic pollution load. Similarly, in the study of Lake Beratan, COD levels exceeded quality standards, although specific figures were not provided (Patida,2022). These variations highlight fluctuations in water quality influenced by human activities. For example, during a lockdown period, a lake demonstrated COD levels within acceptable limits due to reduced human activities (Premsudha et al.,2022). Conversely, tourist areas showed COD values surpassing quality standards, indicating pollution from domestic and agricultural activities (Fatimah et al.,2021). Additionally, Buyan and Tamblingan Lakes exhibited high COD levels, suggesting significant organic contamination (Khune et al.,2021). BOD levels varied significantly among Ayyanakeri Lake and Sannakere Lake, indicating differences in organic pollution levels across these water bodies. Our findings are correlated with many studies who also reported varied levels of BOD, for instance, Lake GoverdhanSagar displayed a BOD of 3.96 ppm (Leiva Thafur et al.,2022), slightly increasing to 4.02 ppm in a subsequent study (Molla et al.,2022), suggesting a moderate level of organic pollution. Conversely, Lake Beratan's BOD parameters met quality standards, indicating lower organic pollution levels (Premsudha et al.,2022). In contrast, Lake Hayq exhibited a higher BOD of 6.40 mg/L (Angular Torrejan et al.,2023), signifying a relatively more substantial organic load.

These findings underscore the significance of monitoring and managing water quality to mitigate pollution and support aquatic ecosystems. Additionally, the complex interplay of chemical factors, such as BOD, COD, and others like electrical conductivity and alkalinity, underscores the need for comprehensive assessment approaches. Although the Malijunga Lake study primarily focused on physicochemical parameters, it indirectly suggested that factors like BOD and COD could influence water taste and odor by affecting overall quality (Khune et al.,2021). Moreover, BOD levels within quality standards in Lake Beratan implied a moderate level of organic pollution (Birla and Vedashree,2020), while a study on Lake GoverdhanSagar reported a higher BOD of 4.02 ppm, indicating a higher pollution status alongside elevated COD levels (Sukmawati et al.,2020). These collective findings underscore the varying levels of BOD in lake waters, influenced by natural conditions and human activities, necessitating ongoing monitoring and management to preserve water quality. When comparing fecal coliform levels across Ayyanakeri Lake and Sannakere Lake, notable differences in microbial contamination are evident. Ayyanakeri Lake's fecal coliform count was 18 MPN/100ml, while Sannakere Lake shows a higher count of 78 MPN/100ml, suggesting a higher degree of fecal contamination and potential health risks associated with water use. These variations highlight the diverse pollution sources affecting the lakes and underscore the importance of continued monitoring and management efforts to safeguard water quality and protect public health.Comparatively, fecal coliform contamination in lake water across Karnataka, India, presents a significant public health concern, as evidenced by various studies. For instance, in Gidadakonehalli Lake, Bangalore, severe pollution levels were identified, although specific fecal coliform counts were not detailed, indicating severe pollution (Shekar et al.,2015). Similarly, in the Bangalore district, fecal coliforms, including *E. coli*, were detected in 60% of water samples, indicating widespread bacterial contamination (Ramachandra, and Latha,2014). The River Cauvery, a major drinking water source, showed high levels of fecal coliforms, posing a threat to public health and antibiotic efficacy due to multidrug-resistant isolates (Skariyachan, et al.,2015). Studies in South India's reservoirs and lakes have also shown pollution from fecal coliforms due to inadequate civic facilities, leading to the inflow of untreated wastewater (Chandrashekar et



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al.,2012). Proximity of wells to open sewerage systems in Bangalore resulted in high levels of fecal coliform contamination, exceeding permissible limits (Singh et al.,2009). Ramasandra Lake's water samples revealed high microbial and fecal contamination, indicating a serious public health threat (Latha and Mohan,2013). Heavy metals in lake water pose significant ecological and health risks, with variations in contamination levels and sources across different regions and seasons. The sources of these heavy metals are varied, including agriculture, transportation, chemical industry, steel-making, and natural sources (Yu et al.,2022). Our study on Ayyayanakere and Sannakere Lakes revealed notable variations in heavy metal concentrations compared to broader research conducted across various regions in India. Ayyayanakere Lake exhibited elevated levels of calcium and magnesium, potentially indicating increased mineral content, while Sannakere Lake showed heightened levels of magnesium, chloride, and manganese, suggesting contamination from industrial discharge, agricultural runoff, or natural processes. This aligns with findings from lakes across India, where heavy metal pollution poses significant risks to aquatic ecosystems and human health. Furthermore, the accumulation of heavy metals in sediments and fish tissues in lakes like Varthur Lake, Bellandur Lake, and Kolleru Lake has underscored the bioaccumulation potential and ecological risks associated with heavy metal pollution (Ramachandra et al.,2020;Muniraju and Delvi,2022;Venkataramana and Sandhya,2023). Remediation strategies such as phytoremediation and bioflocculant treatments have shown promise in mitigating heavy metal pollution in lake waters (Dih et al.,2019). Additionally, industrial activities near water bodies, as observed near a thermal power plant in Udupi District, have contributed to heavy metal contamination of groundwater and soil (Shetty et al.,2021). These findings emphasize the urgent need for continuous monitoring, assessment, and implementation of innovative treatment solutions to address heavy metal pollution in Karnataka's aquatic ecosystems (Prathiba and Muralidhar,2022; Das Sharma,2019).

CONCLUSION

The analysis of water quality parameters across Ayyanakeri Lake, and Sannakere lake reveals diverse conditions and varying levels of pollution in these freshwater ecosystems. While, some parameters meet acceptable standards, such as pH and fecal coliform counts, others indicate potential environmental concerns, including elevated levels of turbidity, total dissolved solids, and chemical oxygen demand. Additionally, the presence of objectionable odors and disagreeable tastes further underscores the impact of pollution sources on sensory aspects of the water. The findings highlight the distinct characteristics of heavy metal presence in Ayyayanakere and Sannakere Lakes, indicating potential mineral enrichment and contamination sources, respectively. Understanding these differences is crucial for targeted management strategies to address water quality concerns effectively. Continued monitoring and mitigation efforts are essential to preserve the ecological balance and ensure the long-term sustainability of these freshwater ecosystems.

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Table 1: Water Quality Analysis of Ayyanakeri and Sannakere lakes water

Parameters	Ayyanakeri Lake	Standards	Parameters	Sannakere Lake	Standards
Color	198	300	Color	-	300
Temperature	28	20°C	Temperature	24.7	20°C
Odour	Objectionable	Unobjectionable	Odour	Objectionable	Unobjectionable
Taste	Disagreeable	-	Taste	Disagreeable	-
pH	7.70	6.5-8.5	pH	7.66	6.5-8.5
EC	2500	0-200	EC	2870	0-200
Turbidity	6.9	<10	Turbidity	6.6	<10
TDS	1452	50-250	TDS	80	100
Calcium as Ca	117.5	0-100	TDS	1683	50-250
Total Hardness	434.5	50-250	Total Alkalinity	746.2	-
Magnesium	34.2	30	Calcium as Ca	73.5	0-100
Oil & Grease	Nil	<10	Total Hardness	724.2	50-250
Sulphate as SO ₄	214.4	250	Magnesium	131.3	30
Chloride as Cl	227.9	250	Oil & Grease	8	<10
Nitrate as NO ₃	3.0	<10	Sulphate as SO ₄	69.7	250
Fluoride as F	0.80	1.5	Chloride as Cl	546.9	250
Dissolved Oxygen	6.40	6	Nitrate	6.2	<10
COD	320	20	Fluoride	1.2	1.5
BOD for 3 days at 27°C	105	3	Dissolved Oxygen	3.6	6
Manganese	0.2	0.05	COD	12.8	20
Arsenic as As	<0.003	0.05	BOD	4.2	3
Cadmium as Cd	<0.004	0.01	Manganese	0.09	0.05
Lead as Pb	<0.003	0.1	Mercury as Hg	Nil	0.01
Nickel as Ni	0.5	-	Arsenic as As	<0.01	0.05
Chromium as Cr	<0.006	0.05	Cadmium as Cd	<0.001	0.01
Zinc as Zn	0.12	1.5	Hexavalent	BDL	0.05





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			Chromium		
Selenium as Se	<0.001	0.01	Lead as Pb	0.1	0.1
Boron as B	0.18	-	Nickel as Ni	0.5	-
Barium Ba	0.10	1.0	Copper as Cu	BDL	1.5
Silver as Ag	<0.001	0.05	Zinc as Zn	<0.002	1.5
Total Coliforms	221	-	Free Ammonia	BDL	-
E-Coli	18	50	Iron as Fe	0.24	0.3
			Phosphates	0.1	-
			Residual Chlorine	BDL	-
			Fecal Coliforms	78	100



Figure 1: Study area map showing Bellary



Figure 2: Geographical Location of Ayyanakere lake, Harapanahalli, Karnataka



Figure 3: Geographical Location of Sannakere, Arasikere, Karnataka





Plants and their Medicinal uses in Kitchen Gardens of Bhadravathi Town, Karnataka

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ABSTRACT

This present communication explores the diversity and uses of medicinal plants growing in kitchen gardens of Bhadravathi Town, Karnataka. Information on medicinal uses of plants was collected through direct field surveys and interactive questionnaires with owners, traditional healers and knowledgeable people. A total of 43 species of medicinal plants belonging to 04 habits from 30 different families have been recorded and are used in medicine for various ailments in humans and animals. The study shows that the region is very rich in traditional knowledge and kitchen gardens are endemic to a wide variety of medicinal plants, which provides practical strategies to promote cultivation and conservation of a range of medicinal plants in kitchen gardens. The uses of medicinal plants in Bhadravathi town are discussed in this article.

Keywords: Medicinal uses, Kitchen garden plants, Bhadravathi town

INTRODUCTION

Plants are used as medicine. Hundreds of plant species are recognised for their therapeutic values and used to treat various diseases. People living in remote areas primarily depend on herbal and indigenous healthcare systems of medicines due to Limited access of modern healthcare facilities and their expensive nature. Indian systems of medicine depend on plant materials or their derivatives for treatment of human ailments (Prajapati et al., 2003). About 12.5% of total 4,22, 000 plant species documented worldwide is reported (Schippmann et al., 2002). However, in modern medicine around the quarter of the drugs prescribed to patients are derived from medicinal plants and they





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are rigorously tested. The World Health Organization, estimates some two billion people are largely reliant on medicinal plants. The use of plant, based materials including herbal or natural health products which suppose health benefits, is increasing in developed countries (Gershenzon and Ullah, 2022). Herbal medicines have been in use long ago and they effects the health and boosting the immunity. Phyto-chemicals have pharmacological activity in medicinal plant for their use in modern medicine,. For instances, the bark of cinchona tree contains quinine, licenced for use against malaria. Several studies have been undertaken on the role of kitchen garden as main source of medicinal plants in different parts of the world. Kitchen gardens are nothing but a separate space in the home gardens devoted to grow specific plants of purely functional. Kitchen garden is also a delightful hobby which ensures an inexpensive, regular and handy supply of fresh vegetables and other medicinal Herbs. Hence, it has been practiced by Urban population also. Moreover, the conservation and sustainable utilisation of medicinal plants are important for better management of valuable resources. Therefore, an attempt has been made to document, diversity and uses of medicinal plants grown in the kitchen Gardens of Bhadravathi town.

The main objectives of the present study is to survey the medicinal plants, their uses, cultivation methods and need for kitchen gardening in present days of Bhadravathi town of Karnataka.

MATERIALS AND METHODS

The study was conducted in the selected kitchen gardens of 5 different localities of Bhadravathi town (Figure 1) namely Siddharoodha nagara, Hosamane, Jannapura, Huttha colony & Paper town.

Sampling Method

27 Kitchen gardens were selected randomly for the present survey. Information of medicinal use was collected during 2 weeks before the survey by interviewing the house owners through interactive questionnaires focusing on local names, parts used and modes of preparation, use and maintenance. Plant species were identified on the basis of vernacular names, floras, and relevant references (Purabhisikia and Mohammed Latif Khan,2011). On the basis of their growth habit and utilization pattern as provided by the informants, medicinally important plant species were categorized into three different categories such as species cultivated exclusively for medicine, species cultivated for medicinal and household purposes.

RESULTS

The results are depicted in Tables 1-2 and Figure 2-5. In the present study, out of 43 species encountered and have different medicinal utilities. These belong to 31 families which were used in preparation of medical remedies against different ailments of both human being and their livestock. Most commonly represented families of medicinal plants were of which Lamiaceae contributed the highest number of exotic species. The medicinal plants cover a wide range of higher plants belonging to 14 herbs, 12 trees, 14 shrubs. Out of the total medicinal flora of the studies kitchen gardens, 23 species were cultivated and rest 21 species were spontaneously grown weed. Among these, 10 species were cultivated solely for medicinal purpose, species 13 cultivated primarily for other household utilities as well as for medicinal utilities and remaining some species were weedy in nature. Though few of the medicinal plants were common in majority of home garden, variation in medicinal plants occurrence were also observed in the studied home gardens. Majority of plants are used for external application and oral consumption (Figure 3). Medicinal plants are mainly using different plant parts and extracts for primary treatment of large number of diseases like pain, cough, cold, fever, jaundice, allergies, dysentery and diarrhoea. Most commonly used plant parts are leaf, young shoot, stem, bark, fruit, flower, seed, root and rhizome. Among all the plant parts, are most frequently utilized one is leaf. Different plant parts in various formulations such as decoctions, infusions, fresh extract, juice or paste are used to get relief from various ailments. Additive like honey and milk are also added in some formulations. Mode of medical administration for different ailments is also different and includes inhalation, instillation and chewing, oral absorption, applying and rubbing. Most of the remedies are administered orally and externally by applying or





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rubbing. Maximum gastro-intestinal, respiratory tract infection, kidney and urinary remedies are used orally while dermatological remedies are applied topically. Most of the species were found having more than a single therapeutic use. Few medicines are prepared only from single plant species and some others are prepared from mixtures of two or more different plants details of the different medicinal remedies of common plants documented from home gardens are enumerated in table.

Centella asiatica:- Memory enhancer, Has powerful antioxidants, Prevent anxiety and stress, Lowers Blood Pressure level. *Azadirachta indica*- Malaria, indigestion, Intestinal worm, menstrual pain, Measles, Burning, Snake bite, Skin disorder, Tooth infection. *Citrus sp*- Black spot in face, Indigestion, Treat Scurvy, Sore throat, Rheumatism, High Blood Pressure. *Curcuma longa* - Anaemia, Antiseptic, Pain, Cuts and wounds *Hibiscus rosa-sinensis*:- Hairfall, Burning, Skin afflictions, Dry cough Paste is applied for both hairfall and burning. *Mentha sps*- Gastric, Acidity.

Ocimum sanctum:- Cough, Asthma. *Momordicacharantia*- Intestinal worm, Malaria. *Leucas aspera*-Snake bite, Intestinal worm, Antifungal, Cold, Antioxidant, Antipyretic, Antibacterial. Herb has the ability to help reduce fever, Juice of the flowers is used to treat intestinal worm and infections in children, Leaf is boiled with water and the water is given for cold. *Carica papaya*- Dengue, Malaria, Abortifacient, Purgative, Asthma. *Piper nigrum*- Insomania, Oral abscesses, Sunburn, Tooth ache, Cold and fever. *Zingiber officinale*- Antihelmentic, Antibacterial, Anti inflammatory, Used for muscle pain, curbs, cancer growth, Lowers Blood sugar, eases menstrual cramps, Lowers cholesterol, relieves indigestion, Nausea, Arthritis. *Murraya koenigii*- Used as herb in ayurvedic and sidda medicine because of anti disease property, helps in treatment of dysentery, diarrhoea, morning sickness and nausea. It is rich source of vitamin A,B,C and Calcium, Iron etc.

Amaranthus tricolor-Treat infalmmatioin, used as diuretic, Antimicrobial, Antidiabetic, Gastroprotective, Antioxidant, Cardio protective, Anti malarial. *Cyanodon dactylon*-Anasarca, Cancer, Convulsions, Cramps, Diarrhea, Dropsy, Epilepsy, Headache, Haemorrhage, Hypertension, Hysteria, Measles and Rubella. *Basella alba*- Gastro protective activity, ulcer healing, anti-inflammatory, boosts libido in males, safe laxative in pregnant women and children, healthy eyesight, Prevent diabetes.

Moringa oleifera-Anti-tumor, Anti Pyretic, Anti-pyleptic, Anti inflammatory, Anti ulcer, Anti spasmodic, Diuretic, Anti-Hypertensive, Lowers cholesterol, Anti-oxidant, Anti diabetic, Mal-nutrition relief. *Piper betle*- Diabetes, Lower cholesterol, Anti-microbial property, Asthma, Improve oral health, Protect gastric system, Helps depression, Heals wound, Increase appetite, Dry cough. *Colocasia esculenta*- Controls Blood sugar, Improves digestive health, Healthy heart, Improves vision, Skin health, Weight loss, Reduce fatigue, Improves blood circulation, Boosts immune system. *Mimosa pudica*- Used for prolonged bleeding, Fasten wound healing, Diarrhoea, Amoebic dysentery, Piles, Gynecological disorders, Skin diseases, Bronchitis,

Calotropis gigantean- Bacterial infections, lever and spleen diseases, Anti-Cancer Properties, Anti dot for snake bite, Arthritis. Used to treat fever, Elepahantiasis, Nausea, Vomiting, Diarrhea, Skin, digestive, respiratory, circulatory and Neurological disorders. *Nyctanthes-arbor-tritis*- Leaves have been used in ayurvedic medicine and Homeopathy for sciatica, Arthritis, Fevers, Malaria, Chicken gunya, Dengue, Anti allergic, Anti-viral, Anti-bacterial, Treat cough, Prevent radicle damage to body, sedative effect, Anti leishmanial activity, Anti-cancer. *Vinca rosea (Catharanthus roseus)*-Anti- Cancer, Diabetes, High blood pressure, Stroke. Vinblastin and Vincristin are used in treatment of Leukamia and Hodgekin's Lymphoma

Phyllanthusniruri- To treat urinary tract stones, Ulcers, Anti- Diabetic, Wound healing, Immuno modulatory activity, Anti oxidant, Anti infalmmatory, Hepato protective. *Phyllanthus emblica*- It is rich in Vitamin C and Anti-Oxidants, enhances gastro intestinal activity, Fortifies lever, Nourishes brain, Strength then lungs and eyes, Enhances fertility, Good for Heart and urinary system, Promotes good skin and healthy hair. *Impatiens balsamina*- Rheumatism, Fractures and other ailments. Juice from leaves is used to treat warts and snake bite, flower is applied to burns, Constipation, Gastritis, Hair growth.





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Tinospora cordifolia- Anti-diabetic, Fever, Jaundice, Chronic diarrhea, Cancer, Dysentery, Bone fracture, Pain, Asthma, Skin disease, Poisonous insect and snake bite, Eye sight, Aphrodisiac. **Clitoria ternatea**- Memory enhancer, Nootropic, Anti-Stress, Anxiolytic, Anti-Depressant, Anti-convulsent, Tranquilising, Sedative agent

Psidium guajava- Diarrhea, Dysentery, Gastro enteritis, Hyper-tension, Diabetes, carries Pain relief, Cough, Oral ulcers, Liver damage, Inflammation, Hair lice. **Oxalis acetosella**-Anti-inflammatory, Diuretic, Anti-pyretic, Used to treat snake bite and applied to abscess, Cough, Diabetes, Bronchitis, Psychiatric disease, Eye disease, Skin disease.

Punicagranatum- High blood pressure, Athletic performancy, Heart disease, Diabetes, Anti-cancer, Alzheimers disease protection, Digestion, Anti-oxidant, Anti-inflammatory, Arthritis. **Aegle marmelous**- Anti-diarrheal, Anti-microbial, Anti-viral, Radio protective, Anticancer, Chemo preventive, Anti-Pyretic, Ulcer healing, Anti-genotoxic, Diuretic, Anti-fertility, Anti-inflammatory. **Coelus amboinicus**-Cold, Asthma, Constipation, Cough, Head ache, Fever, Inflammation and Skin disease. **Mirabilis jalapa**- Diuretic, Pergative, Aphrodisiac, Vulnerary, Treatment of Dropsy, Reduce inflammation.

Solanum nigrum-Ulcer, Skin disease, Asthma, Whooping cough, Analgesic, Sedative, Stomach complaints, Fever, Tuberculosis, Gastric ulcers, Anti-inflammatory, Anticarcinogenic. **Aloe vera**-Enhances skin health, Treats acne, Inflammation, Constipation, Immune booster, Cures gum diseases, Lower high cholesterol, Stabilizes blood sugar, Regulate weight and energy levels, Reduces heart attack, Treats stretch marks and sun burn, Anti-aging, Promotes hair health, Reduces menstrual pain

Euphorbia hirta- Used to treat breathing disorders including Asthma, Bronchitis, Chest congestion, Nose and throat musilage, Throat spasms, Hay fever and tumor, Diarrhoea, Menstrual cramps, Urinal blockage. **Alternanthera sessilis**- Diuretic, Cooling, Disuria, Haemorrhoides, Good for eyes, Anti-Hypertensive, Anti-asthamatic, Anti-spasmodic
Preparation and mode of use: Orally used as tonic

Acalypha indica-Jaundice, To reduce Phlegm and in treatment of cough, Asthma, Breathing problems, Constipation. It is Anti-helminthic, Anti-inflammatory, Antibacterial, Anti-cancer, Anti-diabetic, Anti-Hyperlipidemic, Anti-obesity, Anti-venom, Hepato protective, Hypoxia and wound healing, Skin problems. **Santalum album** -Treats common cold, Bronchitis, Skin disorders, Heart ailments, General weakness, Fever, Infection of urinary tract, Inflammation of mouth and pharynx, Liver and Gall bladder complaints and other maladies
Preparation and mode of use: Oil is used externally

Musa sps-Increases digestion capacity, Prevent anaemia, Reduce menstrual pains, Prevent ulcers, Provides energy, Helps bones to grow stronger, Regulate bowel system, Kidney stones, Heart diseases, Neural disorders, Weight loss, Detoxification. **Tectona grandis**-Inflammation, Pain relief, Poisoning and burning, Increases blood, Hair enhancer, Treats itchiness, Biliary disorders, Urino-genital disorders, Diuretics, Cough, Fever. **Mangifera indica**-Regulates diabetes, Lower blood pressure and risk of Hypertension, Dissolve gall and kidney stones, Treats restlessness, Respiratory problems, Dysentery, Hiccups, Burns, Various stomach ailments, Ear aches, Anti-cancer, Stomach ulcer, Healthy skin, Nausea, Bleeding nose, Anti-fungal, Anti-bacterial, Anti-helminthic

Bacopamonnieri- entire plant is used in insanity, epilepsy, pox, improves intelligence, fever, cough and inflammations.

DISCUSSION

India has a special position in the world due to its capability in producing most of the important plants used both in modern as well as traditional systems of medicine. Medicinal plants can be valued not only for their short term economic benefits but also for cultural richness and the sustenance that they offer to large number of households. The





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present study indicates that home gardens of Bhadravathi harbour a great diversity of medicinal plants with 23 cultivated species and 21 weedy growths. Here, the weedy grown plants are almost equal to the cultivated plants. This is mainly due to owners growing interest towards daily household needs and other commercial cash crops as food supply economic enlistment is the primary aim of the home garden owners'. The present study reported 43 medicinal species present in 27 home gardens. Moreover, the percentage of indigenous medicinal flora is higher than the exotic flora in the region home garden is maintained on the basis of owners' needs and interest. In the present study, we recorded leaf as the most frequently utilized plant parts followed by fruits. The leaf is used for 41 medical remedies as the most frequently utilized plant parts followed by the root used for 34 medical remedies, fruit used for 21 medical remedies and flower is used for 23 remedies. The leaf decoction of *Catharanthus roseus* is used against diabetes, whereas, it is also used it as anti-carcinogenic agent. In some remedies, two or more plants or plant parts are used jointly in the present report. This may be due to either synergistic or additive effects of the is constituents that have been observed over the years. The predominance of remedies for gastrointestinal disorders by oral absorption and dermatological infections by external use agrees with data from other regions of world. Thus, the present study validates that plants and plant extracts used by Bhadravathi people have promising therapeutic properties and the active ingredients of these plants may be further characterized and tested for their safety and efficacy to uncover their therapeutic potential. Although, a few cultivated medicinal species like *Psidium guajava*, *Murraya koenigii*, *Moringa oleifera*, Papaya etc. were found in more than 50% studied home gardens. Most of the species were found only in one to two studied home gardens and require intensive care and habitat management for further existence. It is necessary to find out suitable ways for effective domestic and commercial utilization of medicinal species to ensure their sustainability. Cultivation of medicinal plants is safe both economically and ecologically. Therefore, cultivation is suggested as an alternative way for conservation and management of the medicinal plant species and also to fulfil the market their role as a main source of medicinal plants in demand and local needs. Studies on ecological conditions required for natural regeneration and habitat management is another prerequisite to conserve these resources.

MEDICINAL USE

People of Bhadravathi city area are mainly using different plant parts and extracts for primary treatment of a large number of diseases like pain, cold, cough, fever, jaundice, dysentery and diarrhoea. Most commonly used plant parts are leaf, young shoot, stem, bark, fruit, flower, seed, root and rhizome. Among all the plant parts, most frequently utilized one is leaf followed by fruit. Different plant parts in various formulations such as decoction, infusion, fresh with medicinal and other multifarious utilities. The extract or paste is used to get relief from various ailments. Additives like honey and milk are also added in some formulations. Mode of medical administration for different ailments is also different and includes inhalation, instillation, chewing, oral absorption, applying and rubbing. Most of the remedies are administered orally and externally by applying or rubbing. Maximum gastro-intestinal and kidney and urinary remedies are used orally and dermatological and snakebite remedies are used externally. Highest number of species is used in different formulation to treat gastro intestinal ailments (gastric, indigestion, constipation, diarrhoea, dysentery, intestinal worm, stomach ache, and other stomach problem) while some species is used in respiratory tract infections (fever, headache, asthma, cold and cough) and some species are used in kidney and urinary ailments (kidney stone, jaundice, diabetes, urinary disorder). Most of the species like *Azadirachta indica*, *Curcuma longa*, *Ocimum sanctum* were found having more than a single therapeutic use. For example, different plant parts of *Azadirachta indica* in different formulation are used in treating a range of diseases like intestinal worm, skin disorder, tooth infection, indigestion, malaria, menstrual pain, measles, burning and snakebite. A few medicines are prepared only from a single plant species and some others are prepared from mixtures of two or more different plants. For example, leaf extract of *Centella asiatica* is used against ear pain. On the other hand, leaf of *Indica* mixed with bark of *chebula* and fruit of *Piper nigrum* are pounded to extract the juice and used for the treatment of menstrual pain.

Cultivation of Kitchen garden

A balcony or terrace with 6-7 hours of sunlight is suitable for this. Remove any rubbish or weeds and till the garden well. After that, improve the soil with compost or cow manure before planting. Recommend growing the seeds in pots filled with soil and transplanting them into the garden after a few weeks. Some plants are better planted





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indoors, while others can be sown directly outdoors. Water the garden thoroughly twice a week, but reduce watering in winter. If have potted plants, check the water level by poking the soil with finger. If it looks dry, water generously. Provide supports or trellises for climbing plants such as cucumbers, tomatoes, beans, and squash, as many of them are vines. Also try vertical gardening by using planters on walls and railings. To avoid competition between plants for nutrients and moisture, always maintain a distance of 45-90 cm between rows or plant the plants in individual containers. Practice intercropping by growing some plants together as companion plants. Raised beds are a viable option for creating vegetable gardens because they are easy to maintain.

CONCLUSION

The knowledge and use of medicinal plants is still very much alive among people. The present study indicates that the home gardens harbour a high diversity of medicinal plants. Despite gradual socio-cultural transformation, people still possess of curative properties of different plants and their formulations. It is very essential to compile and document the available knowledge of our rapidly eroding valuable plant resources and to prove their curative properties through detailed phytochemical, biological and pharmacological investigations. Validation and commercialization through wide cultivation of these medicinal plant resources can also provide subsistence and livelihood to the farmer as well as conservation of these rich genetic resources.

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Table 1: Occurrence of Plants in number of houses of Bhadravathi taluk

Sl.No.	Plant Name	Number of houses
1.	<i>Curcuma longa</i>	6
2.	<i>Zingiber officinale</i>	7
3.	<i>Murraya koenigii</i>	22
4.	<i>Carica papaya</i>	17
5.	<i>Amaranthus tricolor</i>	3
6.	<i>Cyanadon dactylon</i>	20
7.	<i>Basella alba</i>	15
8.	<i>Occimum sanctum</i>	26





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9.	<i>Citrus limon</i>	7
10.	<i>Moringa olifera</i>	16
11.	<i>Azadirachta indica</i>	7
12.	<i>Mentha viridis</i>	13
13.	<i>Piper betle</i>	11
14.	<i>Hibiscus rosa-sinensis</i>	25
15.	<i>Leucasaspera</i>	12
16.	<i>Colocasiaesculanta</i>	3
17.	<i>Bacopamonnieri</i>	6
18.	<i>Mimosa pudica</i>	25
19.	<i>Calotropis gigantean</i>	3
20.	<i>Nyctanthes arbor-tristis</i>	2
21.	<i>Vinca rosea</i>	17
22.	<i>Phyllanthus niruri</i>	5
23.	<i>Phyllanthus emblica</i>	4
24.	<i>Impatiens balsamina</i>	11
25.	<i>Tinspora cordifolia</i>	6
26.	<i>Clitoria ternatea</i>	10
27.	<i>Momordica charantia</i>	7
28.	<i>Oxalis acetosella</i>	15
29.	<i>Psidium guajava</i>	10
30.	<i>Punica granatum</i>	5
31.	<i>Aegle marmelos</i>	1
32.	<i>Coelusamboinicus</i>	8
33.	<i>Mirabilis jalapa</i>	1
34.	<i>Solanum nigrum</i>	14
35.	<i>Aloe vera</i>	15
36.	<i>Euphorbia hirta</i>	17
37.	<i>Alternanthera sessilis</i>	17
38.	<i>Acalypha indica</i>	16
39.	<i>Piper nigrum</i>	1
40.	<i>Santalum album</i>	2
41.	<i>Musa sps.</i>	16
42.	<i>Tectona grandis</i>	1
43.	<i>Mangifera indica</i>	9

Table 2: Family wise occurrence of plants in Kitchen gardens of Bhadravathi town

SI.No.	Family Name	Number of Plants
1.	Lamiaceae	4
2.	Rutaceae	3





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3.	Zingiberaceae	2
4.	Amaranthaceae	2
5.	Fabaceae	2
6.	Apocyanaceae	1
7.	Asclepiadaceae	1
8.	Euphorbiaceae	4
9.	Cariaceae	1
10.	Poaceae	1
11.	Basellaceae	1
12.	Moringaceae	1
13.	Meliaceae	1
14.	Piperaceae	2
15.	Malvaceae	1
16.	Araceae	1
17.	Scrophulariaceae	1
18.	Oleiaceae	1
19.	Balsaminaceae	1
20.	Menispermaceae	1
21.	Cucurbitaceae	1
22.	Oxalidaceae	1
23.	Myrtaceae	1
24.	Lythraceae	1
25.	Nyctaginaceae	1
26.	Solanaceae	1
27.	Asphordilaceae	1
28.	Santalaceae	1
29.	Musaceae	1
30.	Anacardiaceae	1
31.	Verbenaceae	1



Figure 1: Study area map of Bhadravathi town

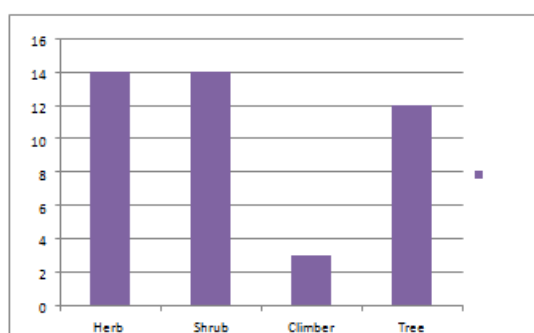


Figure 2: Habit of plants in Kitchen gardens of Bhadravathi town





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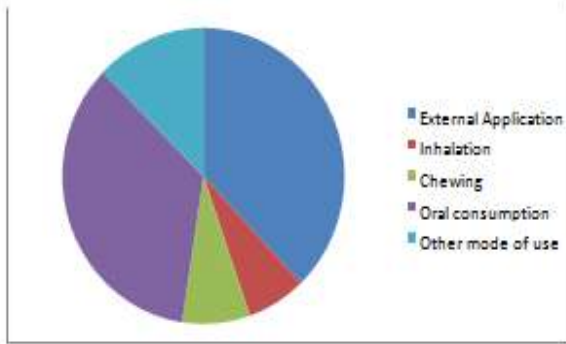


Figure 3: Mode of application of plants used in Bhadravathi town

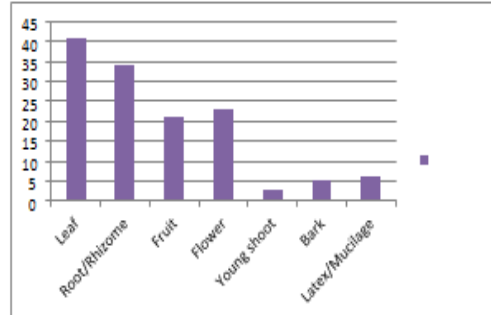


Figure 4: Plant parts used for various ailments in Bhadravathi town



Figure 5: Plants of Kitchen gardens of Bhadravathi town





Institutional Credit to Agriculture in Karnataka: A Review

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ABSTRACT

Institutional credit to Agriculture in Karnataka is reviewed based on published literature as worked out by various researchers. The agricultural sector in Karnataka has benefited greatly from institutional credit flow, which has increased significantly. The effective interest rate has been reduced to 3% per year to the government's interest subsidy program for farmers who pay back their short-term crop loans on time. The commitment of commercial banks to the agrarian acknowledge is most elevated for 70% followed by Co-operative banks and RRB. The effectiveness of the credit can be seen in the higher credit-to-total GDP and agricultural GDP ratios. Linear regression was used to look at the factors that affect the growth of total agricultural output. It was found that credit has a significant relationship with agricultural output at a probability of 10%. All of the variables, with the exception of pesticide consumption, have an effect on agriculture credit, according to the analysis of the determinants of the supply of institutional credit. Credit flow is influenced the most by gross cropped area, followed by GDP and gross irrigated area. To modernize their farming operations, the farmers heavily rely on credit systems. The findings demonstrated that formal farm credit has a significant impact on modern farm inputs. One notable outcome was that farmers were able to acquire inputs like high-quality seeds, fertilizers, pesticides, and farm machinery thanks to their increased credit capacity. Overall, the agricultural sector's growth and development depend on the flow of institutional credit.

Keywords: Agriculture, institutional credit, NABARD, KSFC, Production function, Self help group, Karnataka.





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INTRODUCTION

The first co-operative society of our country was registered in 1905 at Kanaginahal village of Gadag district in Karnataka.(Annual Report for 2009-2010). The Mysore Co-operative Societies Act 1959 is the first legislation in our sate pertaining to the co-operative societies and has come into being from 25-05-1960. Karnataka occupies third position in the economic condition of people involved and has spread to almost all sectors of economic activities, both in rural and urban areas. Karnataka is the first state where in Agricultural loans through co operatives are available at 3% which is lowest in the country. This facility is also extended to the loans borrowed by weavers and fishermen (Ibid). Since the implementation of the recommendation of Prof Vaidyanathan Committee through MOU with Government of India, NABARD and state Government in March 2008, the role of the state Government in respect of Agricultural credit structure Institutions has been metamorphosed from the role of regulator, supervisor to the role of being a Friend, Philosopher and Guide. All statutes, circulars, orders which were coming in the way of day to day internal affairs of the institutions have been withdrawn. Karnataka has a good banking network system which is spread across all the rural areas. There are 27 public sector banks, over 16 private sector banks besides 6 Regional Rural Banks operating in the State. 65% of the total banking business turnover in the State is concentrated in 7 major banks having lead responsibilities in the State. A few new generation banks such as IDRI Bank, Axis Bank, ICICI Bank, Indus Bank, Kotak Mahindra Bank, etc., are also in the banking arena in the State catering to the credit needs of people. The rural credit dispensation in the State takes place through co-operatives, commercial banks and Regional Rural Banks., Of the two major state run lending institutions, the Karnataka State Financial Corporation (KSFC) supports industry and service sectors, the Karnataka State Industrial Investment and Development Corporation (KSIIDC) undertakes promotion and development of medium and large scale industries in the State and acts as a nodal agency to formulate proposals for implementation of infrastructure projects.

The National Bank for Agriculture and Rural Development (NABARD) as an apex level institution prepares the potential Linked Credit Plans (PLPs) every year. Annual action Plans at district level are based on the PLPs prepared by NABARD.¹ Apart from this, NABARD also bring out the State Focus Paper, which covers among other things agriculture and rural economy of the state, performance of rural credit delivery system, policy initiatives of Union and State Governments and NABARD's involvement in supporting credit, developmental and supervisory functions. The State Focus paper is discussed at length in a meeting of Secretaries of various Government departments specially convened for the purpose before pronouncing the credit policy initiatives for the State. NABARD has opened district level offices for better credit planning and monitoring, improving the financial health of rural credit institutions, by creating opportunity for the rural poor to have access to institutional credit through innovations in micro finance like promotion of Self Help Groups (SHGs) and development of rural non-farm sector etc., establishing separate fund for specific activities like promoting infrastructure in rural areas and conservation of scarce land and water resources through watershed management. NABARD is also vested with the power to review Service Area Monitoring and Information System (SAMIS). The working group constituted with the representatives of RBI, NABARD, IBA and nine Commercial banks reviews all aspects of existing SAMIS, constrains in its stabilization and recommends changes to address deficiencies in the system and taken care of future needs of the banking industry. As at the end of March 2009, the total number of bank branches was 5504.

There were 755 bank branches at the time of nationalization in 1969. Since then 4816 bank branches have been added till the end of June 2009, taking total number of bank branches to 5571. out of which 3390 bank branches are located in rural and semi urban areas. At present, the share of rural bank branches in Karnataka Stands at 39.74% as against 25% at the time of nationalization. The per branch population in the state stood at 9593 as at March 2009. The aggregate outstanding deposits of commercial Banks (including RRBs) Stood at Rs. 256709 crore as at the end of March 2009 as against Rs. 210349 crore recorded a year ago. Growth in deposits during the year was 22.04% up to the end of March 2009. As at March 2009, the total outstanding advances of commercial Banks including RRBs in the state stood at Rs. 196719 crore as against the level of advances of Rs. 164110 crore recorded a year ago indicating a growth rate of 19.87%. The credit-deposit ratio (C-D ratio) of the state as of June 2009 was 75.22% vis-a-vis 79.45% as





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of June 2008 showing a decline of 4.23%. The performance of commercial banks in Karnataka from 2006-07 to 2008-09 is given in Table 2 Domestic banks are required to provide 40 percent of their net bank credit to the Priority sector. The Priority sector advances of all bank groups in the State amounted to Rs. 71810 crore in March 2009 contributing to 45.80% in total advances made by them, thus exceeding the norms fixed by the RBI. Direct advances to agricultural sector by Scheduled Commercial Banks (SCBs) in March 2009 stood at Rs. 29196 crore as against Rs. 25817 crore recorded in March 2008 contributing to 18.79% of total advances made by SCBs. Weaker section advances stood at Rs. 16103 crore. The advances paid to Minority communities amounted to Rs. 6489 crore, marking an increase of Rs. 1473 crores against the advances paid during the last year as on March 2008. Details of advances to priority sectors by commercial banks in Karnataka from 2006-07 to 2008-09 is given in Table.3. Credit disbursed by banks to MSME sectors in the state in March 2009 increased to Rs. 16920 crore from Rs. 13974 crore recorded in the previous year. Advances to SC/STs accelerated to Rs. 5315 crore in March 2009 as against Rs. 5030 crore recorded in March 2008. Similarly, advances to women stood at Rs. 13466 crore in March 2009 as against Rs. 11512 crore made in the corresponding period of 2008 recording a good growth during the period.

Data collection

Secondary data is collected related to the status, issues and future agenda of institutional Agricultural credit in Karnataka by referring books, journals, monographs and conference/scientific papers. The data is compiled in the form of a review paper

Implementation of Rural Infrastructure Development Fund (RIDF) in Karnataka.

Government utilized institutional finance from National Bank for Agriculture and Rural Development (NABARD) under Rural Infrastructure Development Fund Scheme for financing various developmental programmes in the state to supplement plan financing. In order to select and priorities the works for loan assistance from NABARD a Cabinet Sub-Committee on RIDF has been constituted under the chairmanship of the Hon'ble Minister for Public Works. A High Power Committee (HPC) has also been constituted chaired by the development Commissioner for reviewing the implementation of RIDF projects in the State. The progress in the implementation of the scheme is also being monitored by NABARD from time to time. Government of India, in 1995 announced the scheme for setting up of Rural Infrastructure Development Fund (RIDF) within the apex institution, NABARD for financing rural infrastructure projects. Domestic Scheduled Commercial Banks, both in the public and private sectors which are unable to meet their targets for priority sector/agricultural lending are required to deposit the shortfall amount in to the RIDF with NABARD such amounts as may be allocated to them by the Reserve Bank, depending upon the extent of their shortfall, subject to a ceiling of 1.5%. The benefits accrued from RIDF programme are unlocking of sunk investments already made by State Governments, creation of additional irrigation potential, generation of additional employment, all-weather connectivity/ improved connectivity to villages and marketing centres and improvements in the quality of life through facilities in education, health and drinking water supply. The initial corpus fund was Rs. 2000 crore in 1995-96 and this fund has since been magnified with an additional corpus being announced every year in the Union Budget and has reached Rs. 88,359 crore from tranches I to XIV. Karnataka got the allocation of Rs. 728 crore from implementing works under RIDF-XV. The rate of interest on loans to State Governments is charged at 6.5% from RIDF tranche VIII and onwards.

Programme status

In Karnataka, till 31-03-2009 an aggregate amount of Rs. 4910.41 crore has been sanctioned by the National Bank for Agriculture and Rural Development (NABARD) under various tranches of RIDF to the State Government so far since 1995. The completed projects include rural roads, rural bridges; minor irrigation project; rural godowns; rural markets; Anganawadi buildings, primary health centers and school class rooms. 12213 projects have been completed as against 23246 projects sanctioned so far. An amount of Rs.728 crores has been allocated by NABARD under RIDE-XV and proposals regarding school and college buildings, Rural Roads and Bridges, Anganawadi buildings, Minor Irrigation works, SC/ST and BCM Hostels, Rural Gowdons, Panchayat service centers etc., have been forwarded to NABARD for utilizing the same (Economic Survey of Karnataka).





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Integrated Rural Development Programme (IRDP)/ Swarna Jayanthi Grama Swarozgar Yojana (SGSY)

Various programmes such as IRDP, TRYSEM, DWCRA, Toolkits, GKY & MWS were merged to form a new scheme known as Swarna Jayanti Swarozgar Yojana (SGSY) that came into effect from 01-04-1999. Under this programme 10 percent of the funds are earmarked for training, 10 percent for revolving fund, 20 percent for infrastructure development and remaining 60 percent utilized as subsidy for taking economic activities with thrust on group activities. Eligible beneficiaries are identified by the Grama Panchayats with the approval of the Grama Sabha. The greater participation of the Grama Panchayats will enable the Implementing agencies to have greater flexibility in execution and to meet the needs of the local people. To tackle the problem of poverty, programmes have been formulated and implemented and the beneficiaries assisted to acquire productive assets. Self-employment programmes like the Swarna Jayanthi Grama Swarozgar Yojana are implemented in urban areas also. Under some of these programmes lower rates of interest are offered, subsidy provided and a longer time for repayment allowed. These are aimed at encouraging the unemployed to take up self employment. During 2008-09, 635 individual families and 5548 SHGs comprising of 88159 swarozgaries were assisted by providing loan of Rs. 2.16 and 186.08 crore and subsidy of Rs. 0.86 and Rs. 71.41 crore respectively. During 2009-10 disbursements to the tune of Rs. 5.44 and Rs. 175.75 crore of loan and Rs. 1.79 and 63.80 crore of subsidy to 1973 individual families and 5104 SHGs are anticipated. Sanctions and disbursements of loan and the subsidy availed under Swarna Jayanthi Grama Swarozgar Yojana (SGSY) for the period from 2006-07 to 2009-10.

Special Project

Each special scheme is a time bound one with the objective of lifting a definite number of families below the poverty line through self-employment programmes. Organizing the rural poor, providing infrastructure, technology, marketing facilities, training or through other activities, sustainable employment opportunities will be created. Twenty two proposals worth of Rs. 177.76 crore have been submitted to Government of India for sanction. Of which, two projects of Dakshina Kannada, Kolar, Mysore, Bellary, Dharwad and Bagalkote have been sanctioned and released Rs. 23.85 crore, out of which Central share is Rs. 17.94 crore and State share is Rs. 5.91 crore.

Micro Credit Delivery Innovations- Self Help Groups (SHGs)

Despite vast expansion of formal rural credit delivery system, and Implementation of series of anti poverty programmes, the majority of the rural Population still finds itself outside the credit delivery system and continues to depend on local money lenders. This is attributable to the high transaction costs and perceived risks. Self help Groups (SHGs) is the culmination of a pilot study undertaken by NABARD to address the credit needs of rural poor. The focus under SHG bank linkage programme is largely on those rural poor who have no sustained access to the formal banking system. Thus, Micro-finance started by NABARD in 1992 has made rapid strides in recent years. The programme, whose seeds were initially sown in Karnataka, has over the past decade seen many milestones in its progress with active involvement of Government agencies, Non-Governmental Organizations (NGOs) commercial banks and regional rural banks. In Karnataka, the State Government through its Women and Child Development Department is empowering rural women in Stree Shakti Programme.

Present Status of the Programme

Karnataka is the Leader State in using micro finance initiative as an effective strategy to address the credit needs of rural poor. By the end of March 2009 about 94795 SHGs were credit linked involving Bank Loan of Rs. 746.38 Crore during the year.³

Suggestions for promotion and sustenance of SHGs in the State are

- Banks may continue the emphasis on repeat finance to meet growing needs of SHGs.
- Maintain good repayment culture in SHG portfolio.
- Identify, develop and support micro enterprise amongst SHGs members.
- Finance diversified activities from the present traditional farm based activities.
- Devise appropriate Insurance products for SHGs.
- Banks to train staff at various levels on promotion of SHGs on a continuous basis.





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- Several districts of north Karnataka have scope for improvement in credit linkages programme.

Kissan Credit Card

Kissan Credit Card Scheme (KCC) introduced by the Government of India in the year 1998-99 aims at providing adequate and timely availability of credit for the comprehensive credit requirements of farmers under a single window, with flexible and simplified procedure adopting whole farm approach including short term and term credit needs and reasonable Component for consumption purpose. The scheme has made rapid progress with the banking system in the state. The banking system has been releasing crop loans through KCCs having recognized it as an accepted mechanism of delivering of credit to farmers. During 2008-09 a total number of 734759 Kissan Credit Cards have been issued by the banking system including Co-operative s in the State involving a credit limit of Rs. 6374.56 crore. This is in comparison to cards with a credit limit of Rs. 4412.91 crore deployed in the corresponding period a year ago. In the current fiscal 2009-10 up to the end of June a total number of 371885 cards with a credit limit of Rs. 2148.32 crore have been issued by Commercial Banks, Regional Rural Banks and co-operatives in the state bringing the outstandings to 2792189 cards with a credit limit of Rs.1 186S.43 crore. The scheme has also been tied up with Personal Accident Insurance scheme (PAIS) wherein card holders are insured up to Rs. 50,000/- at a nominal premium of Rs. 15 for three years.

Regional Rural Banks (RRBs)

The Regional Rural Banks (RRBs) have evolved into a major institution towards credit dispensation in rural areas over the years since their inception in 1975. RRBs being an integral segment of the banking system with focus on rural poor have also been subjected to various reform measures. As a result they have achieved considerable operational and financial stability in recent years. At the end of March 2009 there were 1177 bank branches of 6 Regional Rural Banks (RRBs) (after their amalgamation) spread over all their districts in the State. These Banks have mobilized Rs.9428.86 crore of deposits at the end of March 2009 and advanced Rs. 8178.07 crore, resulting in a credit-deposit ratio of 86.73%. Priority sector advances made by these banks stood at Rs. 6941.03 crore as of June 2008 showing a growth of 11.48% Direct agricultural advances of Regional Rural Banks amounted to Rs. 5061.61 crore constituting 61.89% of total advances made by those RRBs. The State Government in accordance with the provisions of Section (0) of RRB Act 976 has contributed a sum of Rs. 195 lakhs being 15% contribution towards equity share to the 13 RRBs earlier, From time to time several actions were initiated by Govt. of India for enabling the RRBs to attain viability. Under this exercise State Government have infused financial support to these banks to the tune of Rs. 1753.52 lakh in March 2003 towards their re-capitalization in accordance with the policy decision of the Government of India, as part of reform measures to improve the performance of Regional Rural Banks in the State. The Credit Policy announced by the Reserve Bank of India in 2004 indicated that sponsor Banks in consultation with State Governments would initiate steps for amalgamation of RRBs sponsored by them. Accordingly, 13 RRBs in accordance with the policy decision taken by the Government of India to make these banks more vibrant. 4 RRBs sponsored by Canara Bank were amalgamated into one and renamed as Pragati Grameena Bank. Similarly, another 4 RRBs sponsored by Syndicate Bank were amalgamated and renamed as Karnataka Vikas Grameena Bank. The status position of other RRBs sponsored by the State Bank of Mysore, Corporation Bank, State Bank of India and Vijaya Bank remained unaltered. Now all the six RRBs in the State have attained viability.

State Term Lending Institutions

The Karnataka State Financial Corporation (KSFC) and the Karnataka State Industrial Investment and Development Corporation (KSIIDC) are the two major State term lending institutions engaged in the development of Small/medium enterprises and promotion/ development of medium and large scale industries in the State respectively. While KSFC Supports industry and service sectors, the KSIIDC undertakes promotion and development of medium and large scale industries in the State and acts as a nodal agency to formulate proposals for the implementation of infrastructure projects. Keeping in pace with the changed economic scenario, the KSFC has focused its attention on newer areas of financing such as schemes for financing construction activity, infrastructure development IT Parks, Tourism, Health care, Textiles, Insurance, Agro based industries and Food processing, Engineering etc., As at the end of March 2009 the assistance rendered by KSFC aggregated to Rs. 565.24 crore in





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sanction and Rs.383.92 crore in disbursements as against Rs. 368.15 crore in sanctions and Rs. 303.13 crore in disbursements made in March 2008, registering a growth in sanctions and disbursements. It is anticipated that sanctions and disbursements of the corporation would reach Rs. 570.00 crore and Rs. 430.00 crore respectively in 2009-10. There is no sanction made by KSIIDC in 2008-09. But, Rs. 7.53 crore disbursements were made by KSIIDC. It is anticipated that the corporation would make disbursement of Rs. 15.09 crore in 2009-10 (Table-5).

Non-Performing Assets (NPA) in Banks

The Non-Performing Assets (NPA) in Banks in the State stood at Rs. 4627.01 crore in June 2009 as against Rs.4214.73 crore in March 2008. The NPAs of farm sector accounts for Rs. 802.01 crore in the State in end of June in the current year. There has been satisfactory growth in credit expansion in recent years, which is associated with greater efficiency and better management. At the same time excessive growth in credit without adequate safeguards could lead to some erosion in credit quality. Hence, balance has to be established between credit quality and associated risks, while allowing bank lending to contribute to higher growth. In view of the rapid growth in bank credit, there may be a need for strict management techniques for prudent evaluation of investment proposals.

Agricultural Loan waiver

Under Central Government Loan Waiver Scheme Agricultural loans have been waived in Karnataka as follows:

Interest Subsidy Scheme on Crop Loans to Farmers

Government of Karnataka has sanctioned a interest subsidy scheme on crop loans to farmers. As per the scheme the farmers availing crop loans through Public Sector Banks and Regional Rural Banks in Karnataka up to Rs.50000/- on or after 01.04.2009 and repaying the loans as per due date or earlier are eligible for interest subsidy of 4%. The farmers are facilitated to get crop loan at an interest rate of 3%. The State Government will release the interest subsidy to Public Sector Bank and Regional Rural Banks through State Level Bankers Committee, the Nodal Agency for implementing the schemes.

Interest Subsidy Scheme for Loans up to Rs.50000/- to Weavers and Fishermen @ 3% P/A.

Government of Karnataka accorded sanction for schemes of interest Subsidy for loans up to Rs.50,000/- availed by Weavers and Fishermen from nationalized Banks and Regional Rural Banks and repaid as per due date or earlier to enable them to get loan at an interest rate of 3% P/A. The scheme is applicable to the loans availed by Weavers and Fishermen with effect from 1.4.2009 and 1.1.2009 respectively during this Financial year.

Co-operative Credit

This section highlights the performance of Co-operative banks towards credit deployment and recovery aspects in the state from 2007-08 to 2009-10 and measures initiated to facilitate development and improve their various performance.

Primary Agricultural Credit Societies (PACS)

These credit institutions at the grass root level deal directly with individual borrowers and provide short, medium, and long term credit there are 4697 PACS functioning in the state. In addition to this, there are 21 District Cooperative Central Banks (DCCBs) with 596 bank branches. Karnataka State Cooperative Apex Bank, Karnataka State Cooperative Agricultural and Rural Development Bank (KASCARD) at the state level and Primary Cooperative Agricultural and Rural Development Bank at Taluk level numbering 177 cater to the long term credit needs in the two-tier credit delivery system. The National Bank for Agriculture and Rural Development (NABARD) provides refinance to the Apex Bank and KASCARD Bank As on 31.03.2009, the short term (ST), Medium term(MT), and Long term(LT) loans issued by the Cooperative Credit System in the State was Rs.3290.68 crore, Rs. 114.41 Crore and Rs. 171.89 crore respectively as against Rs 2849.50 crore (ST), Rs.98.54 crore (MT) and Rs.210.43 crore (LT) issued a year ago. While disbursement in Long term (LT) loans indicated a declining trend, there was a marked improvement in the issue of Short term (ST) and Medium term (MT) loans. In the Current fiscal up to the end of Nov 2009, the Cooperative credit System issued ST, MT and LT loans to the extent of Rs.2229.19 crore, Rs.75.62 crore and Rs.48.52





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crore respectively. (Table .6). The Comparative study of Short, Medium and Long term loans were presented in Table 7. As on 30th June 2009, the recovery percentage under short term loans recorded 76.50 as against 68.15 recorded during the year 2007-08. The recovery made under Medium Term and Long Term Loans stood at 65.95 percent as against 42.28 percent and 43.50 percent as against 38.65 percent respectively in 2007-08.

Development Action Plans of DCC Banks and Memoranda of Understanding

DCC Banks and Karnataka State Co operative Apex Bank have prepared Development Action Plan (DAP) to strengthen their financial and organization set up accordance with NABARD. On the basis of this, DAP has been prepared. Memorandum of understanding (MoU) for strengthening the co operative credit structure has been signed by NABARD, State Government and Apex Bank in June 1995. The MOU has been extended for a period of three years from 2000. Similar MoU has been prepared and signed by all the DCC Banks for the years from 2004-05 to 2010-11. These action plans are in operation. The position of working funds of DCC banks was Rs.8701.74 crore as at the end of March 2008. The Annual target for the year 2008-09 is Rs.9611.58 crore and the achievement as at the end of March 2009 is Rs.10174.03 crore. (a growth of 15.16% over the previous year). Deposits in DCC banks, which were Rs. 4639.00 crore as on 31.3.2008 increased to Rs.5237.61 crore by 31.3.2009 (a growth of 12.90%). Of the 21 DCC Banks 18 Banks posted profit during the year 2008-09, 3 Banks continued to suffer accumulated loss.

Business Development Plans (BDP) for Primary Cooperative Agricultural Credit Societies

Business Development Plans (BDP) are being implemented in Primary Credit Cooperative Societies from 1995-96. 4374 societies have been brought under this programme by the end of March 2009. During 2008-09, 4374 societies achieved a business turnover of Rs.4339.74 crore as against the target of Rs.5057.68 crore. Government have sanctioned a sum of Rs.324.50 lakh as grant to 651 societies (including the Integrated Cooperative Development Project) so far for the creation of basic infrastructure facilities such as opening of banking counters and cash chests. In addition to this, the Apex Bank and DCC Banks have sanctioned a sum of Rs.338.50 lakh to 676 societies and Rs.379.91 lakh to 823 societies respectively for the above purpose since 1995-96 till date. The deposits mobilised by the PACS as at the end of March 2009 was Rs. 1472.75 crore. Working capital fund of these 4374 societies brought under BDP was Rs, 4635.29 crore in 2008-09 and now it is projected to increase it to Rs.6161.60 crore during the year 2009-10. The business credit and non-credit (retail business etc.) done during 2008-09 by these societies was Rs. 3773.99 crore and Rs.565.75 crore respectively.

Development Action Plan of Karnataka State Co-Operative Agricultural and Rural Development Bank and Primary Co-Operative Agricultural and Rural Development Banks.

177 PCARD Banks working in the state had a paid-up share capital of Rs.107.01 crore at the end of 2008-09. Target fixed for the year 2008-09 for advancing agricultural loans is Rs. 250.00 crore against which they have advanced Rs. 177.65 crore by the end of March 2009 of which Rs. 87.90 crore were lent to small and marginal farmers and Rs. 6.21 crore to SCs/STs. 28 Banks were considered eligible to get unrestricted finance and 147 are eligible to get restricted finance during 2008-09. Eligibility criteria depends on the NPA level of Banks. The Government has given full stamp duty exemption for all the loans availed by farmer members under agriculture and allied activities upto 2009. The Government has sanctioned a sum of Rs. 2412.02 lakh as compensation to 23838 beneficiaries under the failed well compensation scheme as at the end of March 2008.

Disbursement of Agricultural Loans at 3% through PCARD Banks

State Government has formulated a scheme for disbursement of long-term agricultural loans to farmers at 3% from 01-04-2008 through co operative credit societies. During the year 2008-09 an amount of Rs. 171.89 crore agricultural loan has been disbursed to 23327 farmers.

Agricultural Loans to farmers at 4% through Agricultural Co-operative Credit Institutions.

The State Government has implemented the scheme of lending agricultural loans to the farmers at 4% from 01-04-2006 through Agricultural Co-operative Credit Institutions in the State. During 2006-07, an agricultural loan amounting to Rs. 2471.24 crore has been disbursed to 9.20 lakh farmers. The Government has reimbursed an amount





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of Rs.123.7 crore as difference of interest on behalf of the farmers. From 01-04-2008 the Government has implemented the scheme of lending agricultural loans to farmers at 3%. During the year 2007-08, agricultural loan amounting to Rs.3158.46 crore has been disbursed to farmers. Government has reimbursed an amount of Rs.155.93 crore as different of interest on behalf of farmers.

Waiver of Interest & Penal Interest for the Agricultural Loans Availed from Co-Operative Credit Institutions

Agricultural Cooperative Credit Institutions are advancing agricultural loans to the farmers for agricultural activities. The continuous drought in Karnataka for a period from 2001-2004 has caused severe & unprecedented distress & hardship to the farmers. Considering this aspect, the Government have formulated and implemented the scheme of waiver of the interest and penal interest on Short Term, Medium Term and Long Term loans outstanding as on 31.03.2004 from Cooperative Banks: provided the farmers repaid the principal amount within the stipulated period from 01.03.2005 to 31.05.2006. The Government would reimburse the interest waiver amount to the Cooperative Institutions. Under the scheme an amount of Rs. 1519.38 crore has been recovered from 812305 farmer members with respect to Short Term & Medium Term loans. The waiver of interest and penal interest amount is about Rs.797.95 crore. An amount of Rs.296.57 crore has been recovered from 222970 farmer members with respect to Long-term loans and the waiver of interest amount is about Rs.310.74 crore. Under the scheme, a total number of 1200714 farmers have been benefited. The total agricultural loans recovered under this scheme is about Rs. 1812.46 crore and the Government has to reimburse the waiver of interest and penal interest amount which is about Rs. 1123.92 crore Government has released Rs. 1121.02 crore in this regard.

Co-operative Agricultural Credit Sector Agricultural loans to farmers at 3%

The State Government had implemented the scheme of providing agricultural loans through Cooperative credit institution w.e.f. 01-04-2004 at 6% and subsequently the Government has accorded approval to provide agricultural loans at 4% w.e.f. 01-04-2006. In order to further reduce the interest burden of the farmers, the Government has approved the scheme of providing Short term, Medium term and Long term agricultural loans through co-operative institutions at 3% w.e.f. 01-04-2008. The Scheme has been extended to loans availed by weavers and fishermen also. The Government has undertaken to reimburse the loss to the Co-operative credit institutions by way of Interest Subsidy w.e.f. 01-04-2004.

Revival package for short term Co-operative credit structure

In order to strengthen the short term co-operative credit structure in the State, the Govt. of Karnataka has signed the Memorandum of understanding with Govt. of India and NABARD on 25-03-2008 for implementation of Prof. Vaidhyanathan Committee recommendations. In view of the above the State level implementation committee (SLIC) under the chairmanship of the Principal Secretary to the Govt. Finance Dept. has approved Rs.732.25 crores as the amount under this package pertaining to 4131 PACS coming under the Jurisdiction of 19 DCC Banks as on 31-3-2010. Since there was delay on the part of DLIC of Bidar and South Canara DCC Banks to submit the information, the amount to be received under this package pertaining to these 3 Districts of Bidar, South Canara and Udupi are yet to be placed before the SLIC for the approval. Government of Karnataka has provided budgetary provision of Rs 90.07 Crores as its Share under this package and released Rs.39.53 crores along with GOI Shares of Rs. 139.74 crores as 1st instalment on 31-3-2010. The PACS has to adjust their Share out of their profits within one year by increasing Business turn over. The amount released in the 1st instalment is related to the category 'A' PACS which have attained 50% and above recovery as on 31-3-2004. The two weak DCC Banks viz., KCC Bank Darwad has got major Share of Rs.65.33 crores and The Kolar DCC Banks which has got Rs.9.90 crores as a result of this; these Two DCC Banks have become currently viable. This recapitalization assistance has been utilized effectively for the strengthening of credit structure by adopting the Development Action Plan (DAP) for DCCBs and Business Development Programme (BDP) for PACS to become economical vibrant and sustainable in Three years. The follow up action has been taken to avail the 2nd instalment of the revival package during 2010-11.





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Self help Group

For the up liftment of financial weaker section of the society Self Help Groups have been formulated and provided linkage for lending by banks. The main objective of the scheme is to encourage the weaker section of the society for the development activities under taken by them and encourage thrift. Self Help Group is a homogeneous group of rural poor voluntarily formed to save small amounts out of their earnings which is convenient to all the members .As on 31-03-2010, 157163 groups were formed and 119763 groups were credit linked with a credit Linkage of Rs. 545.19 crores.

The Karnataka State Co-operative Apex Bank Ltd., Bangalore

The Karnataka State Co-operative Apex Bank was established in 1915 and is earning profit since inception. As on 31-03-2010 its own funds was Rs.351.97 crores. Working capital - Rs.6701.33 crores; Deposits - Rs.4479.04 crores.*6

Loan Term Structure

The Karnataka State Co-operative Agricultural & Rural Development Bank advances long term loans to the farmers through 177 Primary Co-operative Agricultural & Rural Development Banks (PCARD) in the State.

Karnataka State Co-operative Agricultural & Rural Development Bank Ltd.

For long-term loaning, the main resources for the Karnataka State Co-Operative Agriculture and Rural Development Bank are floating of debentures. For these debentures Registrar of Cooperative Societies is the Trustee. For the year 2009-10 banks share capital was Rs. 50.13 crore, government share capital Rs. 4.45 crore and working capital of Rs. 1978.10 crore.

Urban and Semi Urban cooperative Banks

Urban Cooperative Banks and Non Agriculture Credit Cooperative Societies cater to the needs of Non Agriculture Credit. The Urban Cooperative Banking Sector in the State has achieved tremendous progress in the Banking Sector and has acquired third place in the country. Apart from Urban Cooperative Banks, Non-Agricultural Credit Cooperative Societies and Employees Credit Cooperative Societies are also functioning and have played a significant role in advancing loans. As on 31 -03 -2010 there are 319 urban banks and 3175 credit perative societies with the membership of 5862000 members and working Capital of Rs.25839.56 crores.

Women Urban Cooperative Banks

Among the above Urban Cooperative Banks, there are 28 Banks organized exclusively for women.

The Karnataka State Cooperative Urban Banks Federation Ltd., Bangalore.

Federation is providing Institutional Assistance to its members in addition; it has 2 separate courts to resolve Disputes pertaining to Urban Banks.

Co-operative Marketing Societies

In Karnataka there are 185 Taluk Agriculture Produce co-operative Marketing Societies. Apart from these societies there are specialized marketing Societies dealing with Commercial Crops like Areca nut etc.,

The Karnataka State Co-operative Marketing Federation Ltd..

It plays a major role in supplying chemical fertilizers, pesticides, seeds, Agricultural implements and other agricultural inputs to the farmers. It is also engaged in marketing certain consumer articles. The Federation also has its own Pesticides formulation Unit in Peenya, where pesticides under the brand name "SAHAKAR" are formulated. As on 31-03-2010, the federation's total share capital is Rs.3867.58 lakhs and business turnover of Rs.62500.00 lakhs.

Processing Cooperative Societies

For Processing of Agriculture and Horticulture produce such as Rice, Dhal, Oil, Cotton, Coffee, Areca nut, Fruits Processing Units are established in the Cooperative sector. Out of these (1) CAMPCO - Mangalore (Areca nut and





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Cocoa Marketing Processing Cooperative Society) (2) COMARK (Coffee) (3) Rubber, Marketing and processing Cooperative Society, Mangalore have been registered under the Multistate Cooperative Societies Act 1984.

There are other Areca Marketing and Processing Cooperative Societies in the Areca growing Districts of the State and they are

1. Karnataka State Areca nut co-operative society Ltd., Shimoga
2. The Totagars Cooperative Sale Society Ltd., Sirsi
3. The Malnad Areca marketing Cooperative Society Ltd., Shimoga
4. The Areca Processing and Sales Cooperative Society Ltd., Sagar
5. Hassan Valaya Arecanut Growers Co-operative Society Ltd. In the State of Karnataka there are 91 Rice Mills which have been established by the TAPCMS. Kodagu Coffee Growers Cooperative Society is registered on 02-01-1956 for processing coffee.

The Karnataka Cooperative Oil Seeds Grower's Federation, Bangalore

The Federation has 371 Oil Seeds Growers Cooperative Societies and 143062 Farmers as members covering 3245 villages. As on 31-03-2010, Federation's share capital is Rs. 179.11 lakhs, business turnover of Rs. 1019 lakhs and net profit of Rs. 179.00 lakhs. (Provisional).

The Karnataka State Cooperative Horticulture Marketing federation Ltd. Bangalore.

The Federation was registered on 25/10/96. The main objective of the Federation is to develop and encourage Horticulture, supply of inputs to farmers, procurement and marketing of produce.

Horticulture Producers Cooperative Marketing and Processing Society Ltd., Bangalore (HOPCOMS)

Horticulture Producers Co-operative Marketing and Processing Society Ltd., (HOPCOMS) was registered in 1959. As on 31-03-2010, the society has 41497 members with share capital of Rs.301.62 lakhs, business turnover of Rs.5649.52 lakhs and net profit of Rs.216.29 lakhs.

Consumer Co-operatives

In Karnataka Consumer Co-operatives are working in 3 stages viz.,

- 1) The Karnataka State Co-operative Consumers Federation Ltd, Bangalore at State level.
- 2) The District Central Co-operative Wholesale Stores at District level.
- 3) The Primary Consumer Co-operative Societies at Primary level.

The Karnataka State Co-operative Consumer's Federation

Federation was registered in the year 1964 and has 24 members, 7 Janatha Bazaars at Bangalore, 7 branches in other Districts and 9 Medical shops. For the year 2009-10, the Federation has share capital of Rs.267.15 lakhs, Government Share capital of Rs.257.90 lakhs and Business turnover of Rs.8692.30 lakhs.

District Central Co-operative Wholesale stores:

There are 30 District Central Co-operative Wholesale Stores in the State of which 25 societies are working.

Consumers Cooperative Societies

There are 1476 Primary Consumers Co-operative Societies in the State. As on 31-03-2010 these societies are having share capital of Rs. 1046.65 lakhs and turnover of 11504.01 lakhs.

Karnataka State Co-operative Milk Federation Ltd.

Karnataka Co-operative Milk Producers Federation Ltd., a co-operative apex body, in Karnataka established in 1984, is implementing Dairy Development activities in the entire state since 3 decades through 13 Milk Unions in Co-ordination with NDDB. Ushering prosperity in the lives of rural Milk Producers. As at the end of March-2010, 11,929 dairy co-operative societies (DCS) have been organized covering 19,154 villages in the 13 Milk Union areas, 10415

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DCS are functioning with 95% of them in profit. 20.34 lakhs farmers are members in these DCS, out of which 6, 60 lakhs are women members. DCS in villages are procuring milk from the member producers twice in a day. The average milk procurement was 35.79 lakhs kg during 2009-10. The surplus milk is converted in to milk products. Karnataka Milk Federation is in second position, as far as milk procurement by CO-operative is concerned, at the National level, and first in South India under co-operative dairies. 22 dairies with a total processing capacity of 26.65 lakhs liters per day, 44 milk chilling centers with chilling capacity of 15 lakhs liters per day, and 5 milk powder plants with drying capacity of 92 M.T. per day are functioning. During the year, 2009-10, an average 24.70 lakhs liters of milk per day was sold. Out of which an average of 13.34 lakhs liters was sold in Bangalore. To meet the demands of consumers, milk products like good life, UHT Milk in different various curds, butter, ghee, flavoured milk (in 8 flavours) Mysore pak, Nandini burfi, Rasgulla, Badam powder, Jambun mix are produced and sold. In addition to these other products like sweet curds; butter milk, ice cream and kunda are being produced and sold.

House Building Co-operative Societies

There are 1493 House Building Co-operative Societies in the State. Out of which 1005 societies are working, 530 defunct and 258 societies are under liquidation.

Karnataka State Cooperative Housing Federation Ltd.,

The Karnataka State Co-op Housing Federation Ltd., Bangalore was registered during the year 1950. As on 31-03-2010 the Federation has got share capital of Rs.633.57 lakhs and working capital of Rs.8924.98 lakhs. The Federation has advanced loan of Rs. 1545.68 lakhs to the House Building Co operative Societies, Industrial Co-operative societies.

Karnataka Plans Farmer Loans At 1 Percent

In the first of its kind budget in the country for farmers, Karnataka proposed to give crop loans at one percent interest rate through cooperative credit institutions in the ensuing fiscal 2011-12. Crop loan will be made available at one percent interest rate to farmers through cooperative credit institutions as against three percent interest rate hitherto "Chief Minister B.S. Yeddyurappa told lawmakers in the assembly, presenting a separate budget for the agriculture sector. The resilient farm sector in the state is projected to grow 5.5 percent this fiscal (2010-11). Mainly owing to above normal monsoon and the food grain production is expected to increase 14 percent over the last fiscal (2009-10), according to the state economic survey report released Wednesday."The difference of interest on account of reduction will be met by the state government, though crop loans up to Rs. 50,000 from commercial banks will continue (to be given) at three percent," the chief minister clarified. Proclaiming to be a farmer's son himself, Yeddyurappa proposed to allocate a whopping Rs. 17,857 crore for the development of agriculture, allied and irrigation sectors in the new fiscal. "A total of Rs. 1,000 crore was provided for the development of one million farmer families under 'Suvarna Bhoomi Yojana' (land enrichment programme)," he said.

The National Bank for Agriculture and Rural Development (Nabard) has estimated a credit flow potential of Rs 41,085.23 crore for Karnataka in 2011-12, an increase of 31 per cent over the previous year. Speaking at the "State Credit Seminar - 2011-12" here, Dr V. Tagat, Chief General Manager, NABARD, Bangalore, said the bank has created potential linked credit plans for all the 30 districts in the State. The Share of crop loans formed 45 per cent of the total potential estimated, owed by other priority sector at 29 per cent, agricultural term loan at 18 per Cent and non-farm sector at eight per cent. Dr. Tagat said the credit flow to crop loans in 2010-11 was Rs 14,622.37 Crore and the potential assessed for financing in 2011-12 was Rs 18,373.51 Crore. The credit flow to water resources sector in 2010-11 was Rs. 947.22 crore and the estimated potential in 2011-12 is Rs 847.44 crore. The cumulative irrigation created under major, medium and minor irrigation touched 34.84 lakh hectares. Credit flow break-up. The estimated credit flow to various activities in 2011-12 is: land development – Rs. 905.94 crore, farm mechanisation -Rs 1,975.62 crore, plantation and horticulture – Rs. 1,415.94 crore, forestry – Rs. 64.99 crore, dairy development –Rs. 668.35 crore, poultry development – Rs. 257.62 crore, sheep goat piggery Rs. 151.05 crore, fisheries – Rs. 134.96 crore, storage godown and market yards – Rs. 561.09 crore renewable sources of energy and waste utilisation – Rs. 59.78 crore, and





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food and agro-processing – Rs. 731-98 crore, other activities – Rs. 678.93 crore, term loan – Rs. 7.553-75 crore, non-farm sector – Rs. 3.365.83 crore and other priority sector – Rs. 11,792.11 crore.

CONCLUSION

Credit plays a crucial role in the growth of agriculture. As a result, credit has played a significant role in the growth of the agricultural sector thanks to institutional credit. The agricultural sector in Karnataka has benefited greatly from institutional credit flow, which has increased significantly over time. The agricultural sector's success and expansion depend on having access to agricultural finance. Farmers now rely primarily on commercial banks for credit, so educating them on the ins and outs of banking procedures could make it easier for them to get credit. In addition, it is recommended to implement and streamline microfinance options in order to effectively link small, marginal, and tribal farmers with Self Help Groups (SHGs).

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Table:1

Name of the Institution	Small and medium Farmers		Other Farmers		Total	
	No. of A/cs	Total	No. of A/cs	Total	No. of A/cs	Total
Commercial Banks	428588	1430.99	264782	754.35	693370	2185.34
RRB	257390	663.12	123390	304.51	380780	967.63
Cooperative Banks	237370	4069.80	65440	95.63	302810	502.43
Total	923348	2500.91	453612	1154.49	1376960	3655.40

Table:2 The SLIC has sanctioned the Recapitalization assistance to the PACS as under on 31-03-2010 (Rs. in Crores)

Category	Total No. of PACS	GOI Share	GOK Share	PACS Share	Total
'A'	1934	139.74	39.53	23.00	202.27
'B1'	595	92.52	14.62	11.26	118.40
'B2'	001	00	00	0.08	0.08
'C'	1482		30.76	28.47	354.55
Total	3912	527.58	84.91	62.81	675.30





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Ineligible PACS	219	45.24	5.16	6.55	56.95
Grand Total	4131	572.82	90.07	69.32	732.25

Table:3 Details of Long Term Loans advances in the last 3 years (Rs. in Crores)

Year	Target	Achievement	% of achievement target
2007-08	220.00	210.43	95.65
2008-09	250.00	177.15	70.86
2009-10	302.00	183.42	60.73

Table:4 Comparative position of aggregate bank deposits & gross bank credit in Karnataka with selected States in the country as on March 2009.(Rs. Crore)

State	Office/ Branch network	Aggregate deposits	Rank	Gross credit	Rank
Maharashtra	7394	1004898	1	912368	1
Delhi	2144	517150	2	354425	2
Uttar Pradesh	9595	264369	3	111185	8
Karnataka	5716	256709	4	196719	5
Tamil Nadu	5841	246992	5	268963	3
West Bengal	5023	228649	6	138969	6
Andhra Pradesh	6443	217453	7	212178	4
Gujarat	4283	187906	8	118684	7
Kerala	4016	135173	9	81612	9
Punjab	3229	120667	10	79064	10
All India	79056	3937336		2857252	-

Source: Quarterly statistics issued by R.B.I.- March 2009.

Table:5 Performance of Scheduled Commercial Banks in Karnataka 2006 to 2009 (End of March)

Sl. No.	Indicator	Unit	2006-07	2007-08	2008-09
1.	Branch Network				
	a) Commercial Banks	No.	3971	4127	4391
	b) Regional Rural Banks	No.	1128	1153	1180
	Total	No.	5099	5280	5571
2.	Deposits				
	a) Commercial Banks	Rs. in Cr.	124725.11	156306.27	198969.51
	b) Regional Rural Banks	Rs. in Cr.	6024.88	7617.52	9428.86
	Total	Rs. in Cr.	130749.99	163923.79	208398.37
3.	Advances				
	a) Commercial Banks	Rs. in Cr.	101831.04	124418.78	148580.82
	b) Regional Rural Banks	Rs. in Cr.	5893.06	7081.58	8178.07
	Total	Rs. in Cr.	107724.10	131500.35	156758.89
4.	Credit-Deposit ratio				
	a) Commercial Banks	%age	81.64	76.88	74.68
	b) Regional Rural Banks	%age	97.81	92.96	86.73
	Total	%age	82.39	80.22	75.22

Source: State Level Bankers Committee, Karnataka





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Table:6 Priority sector advances : 2007 to 2009 (Rs. Crore)

SNo	Indicator	End of March		
		2007	2008	2009
1.	Agriculture & Allied Activities	22149.00	25817.00	29296.00
2.	Small Scale Industries	6295.28	10081.06	16920.00
3.	Tertiary Sector	18645.78	23013.23	26703.66
4.	Total Priority Sector Advances	47090.06	58002.00	71810.00
	Out Standings under PSA:			
	i) SCs & STs	3113.00	5030.00	5315.00
	ii) Weaker Sections	10971.00	13645.00	16103.00
5.	Percentage of Priority Sector advances of total advances	43.71	44.10	45.80
6.	Percentage of weaker section advances to total advances	10.18	10.37	10.27

Source: State Level Bankers Committee, Karnataka

Table 7A: RIDF: Tranche-wise Size of Corpus

RIDF Tranche	Year	Corpus
RIDF I	1995-96	2000
RIDF II	1996-97	2500
RIDF III	1997-98	2500
RIDF IV	1998-99	3000
RIDF V	1999-2000	3500
RIDF VI	2000-2001	4500
RIDF VII	2001-2002	5000
RIDF VIII	2002-2003	5500
RIDF IX	2003-2004	5500
RIDF X	2004-2005	8000
RIDF XI	2005-2006	8000
RIDF XII	2006-2007	9000
RIDF XIII	2007-2008	9500
RIDF XIV	2008-2009	9800
TOTAL	-	78300

Source: 1. NABARD Annual Report 2. RBI Bulletin

Table:8 Swarnajayanti Gram Swarajgar Yojana from 2006-07 to 2009-10 (Rs. Crore)

Category	Year	Sanctions		Disbursements		Subsidy released	
		No.	Amount	No.	Amount	No.	Amount
Individuals	2006-07	2773	6.77	2695	6.58	2695	2.54
	2007-08	1641	6.12	1549	5.78	1549	2.13
	2008-09	709	2.69	570	2.16	570	0.86
Groups	2009-10 (upto Nov.09)	622	2.71	466	2.03	466	0.72





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	2006-07	3543	84.25	3298	78.42	3298	36.67
	2007-08	9107	154.06	8789	148.68	8789	64.91
	2008-09	6325	203.79	5774	186.08	5774	71.47
Total	2009-10 (upto Nov.06)	3260	126.89	2482	96.61	2482	35.81
	2006-07	6361	89.58	5993	85.00	5993	39.21
	2007-08	10748	160.59	10338	154.46	10338	67.04
	2008-09	7034	208.67	6344	188.24	6344	72.33
	2009-10 (upto Nov.09)	3882	129.89	2948	98.64	2948	36.53

Source: Rural Development and Panchayath Raj Department

Table 8A: Beneficiaries under Self Employment Schemes 2006-07 to 2009-10

Programme/ Scheme	2006-07		2007-08		2008-09		2009-10	
	Target	Acht.	Target	Acht.	Target	Acht.	Target	Acht.
SGSY	37603	46407	65032	82158	76834	88794	34768	43493

Table 8B: Swarna Jayanthi Grama Swarozgar Yojana (SGSY) Abstract Progress Report (end of March)

Indicator	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010 (Nov.09)
Beneficiaries (in thousands)	42.94	37.12	43.29	52.98	46.92	46.41	82.15	88.79	43.49
Of which SC/STs (in thousands)	16.16	13.86	17.49	21.31	20.16	31.32	38.97	42.34	20.91
Loan Component (Rs. Crore)	78.15	62.53	65.05	75.60	79.44	84.83	154.46	188.24	98.66
Grant in aid (Rs. Crore)	36.11	34.41	34.91	40.98	40.55	39.21	67.04	72.33	36.53
Total (Rs. Crore)	114.26	96.94	99.96	116.58	119.99	124.04	221.50	260.57	135.19

Table 8C: SHG-Bank Linkage Programme

Year	Total SHGs Financed by banks number in '000		Banks loans (Rs. Crores)		Refinance (Rs. Crore)	
	During the year	Cumulative	During the year	Cumulative	During the year	Cumulative
1999-2000	81.78 (147.9)	114.78 (247.9)	136 (138.6)	193 (238.6)	98 (88.5)	150 (188.5)
2000-2001	149.05 (82.3)	263.83 (129.9)	288 (111.8)	481 (149.2)	251 (156.1)	401 (167.3)
2001-2002	197.65 (32.6)	461.48 (74.9)	546 (89.6)	1026 (113.3)	396 (57.8)	797 (98.8)
2002-2003	255.88 (29.5)	717.36 (55.4)	1022 (87.2)	2049 (99.7)	622 (57.1)	1419 (78.0)
2003-2004	361.73 (41.4)	1079.09 (50.0)	1856 (81.6)	3904 (90.5)	705 (13.3)	2125 (49.7)
2004-2005	539.39 (49.1)	1618.48 (50.0)	2994 (61.4)	6899 (76.7)	968 (37.3)	3092 (45.5)
2005-	620	2239	4449	11398	1068	4160





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2006	(15.0)	(38.3)	(50.3)	(65.2)	(10.3)	(34.5)
2006-2007	686 (11.0)	2924 (30.6)	6643 (47.6)	18041 (58.3)	1299 (21.6)	5459 (31.2)
2007-2008	798 (13.4)	3456 (45.3)	7829 (51.4)	20342 (61.6)	1467 (26.1)	6098 (36.2)
2008-2009	824 (14.3)	4812 (37.5)	8735 (61.5)	22456 (56.4)	1642 (23.5)	7541 (34.7)

Note: Figures in parentheses indicate percentage variations over the previous year.

Data for 2008-09 are provisional.

Source: Report on Trend and Progress of Banking in India, various issues.

Table 8D: Agency-wise and Year-wise KCC Cooperative banks

Year	Cooperative Banks	RRBs	Commercial Banks	Total
1998-99	0.16	0.01	0.62	0.78
1999-2000	3.6	0.17	1.37	5.13
2000-2001	5.61	0.56	2.39	8.65
2001-2002	5.44	0.83	3.07	9.34
2002-2003	4.58	0.96	2.70	8.24
2003-2004	4.88	1.27	3.09	9.25
2004-2005	3.56	1.73	4.40	9.68
2005-2006	2.60	1.25	4.17	8.01
2006-2007	3.80	1.76	4.54	9.54
2007-2008	3.96	1.95	4.21	10.45
2008-2009	4.65	1.99	4.64	10.98
Total	42.82	12.58	35.19	90.59
Share in Total (percent)	47.28	13.87	38.85	100.0

Table 9 : State Term Lending Institutions in Karnataka from 2007 to 2010

Institution	2007-08		2008-09		2009-10 (Anticipated)	
	Sanctions	Disbursements	Sanctions	Disbursements	Sanctions	Disbursements
KSFC	368.15	303.13	565.24	383.24	570.00	430.00
KSIIIDC	0.00	17.72*	0.00	7.53*	0.00	15.09*

Source: KSFC & KSIIIDC ;Investment in equity- Bangalore International Airport Ltd.,

Table 10: Short , Medium and Long Term Credit Structure in Karnataka from 2007 to 2010 (Rs. Crore)

Year	Type of Loan	Target	achievement
2007-08	Short Term	3031.23	2849.49
	Medium Term	137.51	98.54
	Long Term	106.10	210.43
2008-09	Short Term	3422.22	3010.62
	Medium Term	146.00	114.40
	Long Term	218.17	171.89
2009-2010 (as on 30-11-2009)	Short Term	3617.56	2229.19
	Medium Term	158.93	75.62
	Long Term	279.00	48.52





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Table 11 : Recovery of Loans in Karnataka (Percent)

Type of Loan	2007-08	2008-09	2009-10
Short Term	68.15	76.5	52.77
Medium Term	65.95	40.53	42.28
Long Term	38.65	43.50	12.44





***Nerium oleander*: Chemical Constituents, Pharmacological Properties and Recent Scientific Work an Overview**

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ABSTRACT

In Indian traditional medicine, *Nerium oleander* (*N. oleander*) is a valuable medicinal herb. There are also known cases of suicide utilizing *N. oleander* in South Asian countries, including India and Sri Lanka. Cardenolides, gentiobiosyl, odoroside, oleandrin, and neridin are only few of many cardiac glycosides found in all sections of the *N. oleander* plant. This plant species produces a variety of secondary metabolites, including alkaloids, flavonoids, and steroids, all of which have different medicinal uses. It possesses a variety of significant pharmacological effects, such as hepatoprotective, immunopotent, antibacterial, anthelmintic, anti-inflammatory, antioxidant, antifungal, anticancer, and anti-HIV qualities. This objective of this review is to present evidence-based information on phytochemicals and pharmacological effects of *N. oleander*.

Keywords: Anthelmintic, hepatoprotective, immunopotent, anti-pyretic, antioxidant, antifungal, anticancer, and anti-HIV properties of *N. oleander*.

INTRODUCTION

N. oleander belongs to the family Apocynaceae and is a green plant (fig. 1). It is now the sole species identified by formal classification as belonging to the genus *Nerium*. It bears little resemblance to the unrelated olive *Olea*, known by the name "oleander. It is thought to have originated in Southwest Asia and is now extensively grown. Oleander is



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commonly planted as a decorative plant in yards, parks, and by the sides of roadways since it thrives well in warm, subtropical climates [Abderrahim et al., 2017]. Oleandrin, a very lipid-soluble cardiac glycoside, as reported by [Zhai et al. 2022] is the main constituent of the plant *N. oleander* (Apocynaceae). Traditional herbal therapy uses oleandrin due to its excellent pharmacological characteristics. It is frequently used in the treatment of many diseases, including congestive heart failure. Oleandrin's potent antiviral and broad anticancer properties have lately garnered a lot of attention. [Zaid et al., 2022] investigated different cellular models for assessment of plant's toxicity. It was discovered that extract from *N. oleander* has many other beneficial effects on the antioxidant defense system of the cell, including reduction of free radical production in the cells during an inflammatory insult. Benson et al., 2015 investigated and found that the *N. oleander* extract derived from Aloe vera reduces free radical generation within cells and strengthens their antioxidant defense system when an inflammatory stimulus exists or not. Khalid et al., 2023 reported that *N. oleander* should be grown near roadside verges to remove vehicle pollutants, as this could result in long-term management of these corridors. *N. oleander* ethanolic floral extract (NOEE) demonstrated strong anti-inflammatory properties when investigated by Shafiq et al., 2021 in inflammatory models using carrageenan and cotton pellets. They provided scientific validation for the long-standing usage of *N. oleander* flowers to alleviate heightened pain and inflammation, especially in cases of bacterial infections.

Chemical constituents

The plant contains many cardiac glycosides that have properties akin to those of digitalis [Radford et al., 1986] like gentiobiosyl, oleandrin, cardenolides, neriine, and odorside [Duke et al., 1985]. Numerous other potent pharmacological substances found in the plant include oleandomycin, rutin, rosagenin and folinerin [Siddiqui et al., 1997]. The five cardenolides that shown CNS antidepressant effect were found to be neridiginoside and four newly discovered compounds cardenolide, nerizoside, neritaloside, and odorside-H,. It was discovered that neridiginoside had a structure of 3 beta-O-(D-diginosyl).14 (-5 beta) beta-dihydroxy-card-20 (22)-enosil [Begum et al., 1999]. *N. oleander* leaves were found to contain 12 previously identified triterpenes in addition to three newly identified triterpenes: oleanane-type triterpene 2, dammarane-type triterpene and ursane-type triterpene 1 [Dong et al., 2000]. Three new ursane-type triterpenes, 20 beta, 28-epoxy-28 alpha, and 3beta-hydroxyurs-12-en-28-aldehyde; taraxasterane-type triterpenes; 28-nor-Urs-12-ENE-3beta, 17beta-diol, were obtained from an ethyl acetate extract of *N. oleander* leaves [Zhao et al., 2006]. 3-O-caffeoylquinic acid and its structural isomer, 5-O-caffeoylquinic acid, are two examples of chlorogenic acids, were extracted from *N. indica* leaves using hot water. These substances are anti-hyperglycemic medications since it has been demonstrated that they inhibit alpha-glucosidases non-competitively [Ishikawa et al., 2007, Wang et al., 2009, Bai et al., 2007]. Significant antioxidant activity was found in 1-hydroxy-8-glucosyloxy-3, 5-dimethoxyxanthone, 1, 8-dihydroxy-3, 7-dimethoxyxanthone, 3-methoxy-1, 5, 8-trihydroxyxanthone, and ursolic acid are also included, which were shown to be bioactive substances obtained from the aerial portions of *N. oleander* [Chakravarty et al., 1991]. *N. oleander* leaves as a possible source of ursolic acid in light of this discovery. Our study's goals included obtaining, screening, characterizing, and evaluating the plant's anti-inflammatory qualities. [Chakravarty et al., 1991, Rana et al., 2005], Traditional Chinese medicine makes extensive use of oleandrin, a highly lipid-soluble cardiac glycoside that is extracted from the *N. oleander* (Apocynaceae) plant. Congestive heart failure is among the several diseases for which it is commonly used. The toxicity of oleandrin is also extensively studied, and evaluating feasible research approaches to lessen toxicity, a discovery of safe medicinal applications for oleandrin might be achievable [Zhai et al., 2022] structure of ursolic acid is shown below in figure 2.

Botanical Description

The Apocynaceae family includes the *N. oleander*, which is indigenous to South Asia and the Mediterranean. It is a tough shrub that can withstand dryness and is distinguished by its tall, thin stems, lance-shaped leaves, and clusters of colourful, funnel-shaped blooms. Oleander is a well-liked decorative plant in lots of gardens and landscapes because of its several flower colours, which include white, pink, red, and yellow. *N. oleander* has a long and rich history. Numerous ancient manuscripts, including those written by the Greeks and Romans, mention it as having been grown for ornamental reasons for thousands of years. In fact, it's thought that the botanical name "Nerium" comes from the Greek word "nerion," which means "water," probably as a result of the plant's fondness for damp





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soils. Additionally, throughout history, oleander has been mentioned in poetry, literature, and art from various cultures [Poppenga et al., 2020].

Traditional Uses

Traditional medical practices have long used *N. oleander*, especially in areas where it is native. The potential therapeutic properties of the plant's various sections, including the leaves, flowers, and roots, have been explored. Scabies and edoema have been treated externally with a leaf decoction. Bark can be used as a febrifuge and cathartic for sporadic fevers because of its bitterness. The root bark is used to make oil that is used to treat scaly skin diseases like leprosy. As a purgative, seeds are used for rheumatism and dropsy. Because the root is toxic and should only be used externally, it is powerful, dissolves readily, and is used as plasters for tumors. *N. oleander* has diaphoretic, cardiotoxic, and antimicrobial properties in its leaves and petals. *N. oleander* is pounded with water to form a paste that is applied to penile lesions and ulcers. Apart from being beneficial against warts, malignant ulcers, carcinoma, ulcerating or hard tumors, the plant's bark, roots, leaves, juice, and blooms have all been utilized in cancer treatments [Valnet et al., 1976]. In 2011, the Federal Drug Administration (FDA) concluded the first phase of testing with oleander extract and certified it safe for use in cancer treatment. Furthermore, the extract was found to have nearly no cardiotoxicity or adverse side effects and to have a favorable influence on the development of cancers of the breast, pancreas, bladder, colon, and appendix. Advanced cancer patients have been treated with Anvirze, an aqueous extract of the *N. oleander* plant. Additionally, *N. oleander* is used medicinally to treat ulcers, hemorrhoids, ringworm, herpes, leprosy, and abscesses [Pathak et al., 2000, Manna et al., 2000].

Pharmacological properties

Anti-oxidant role

Higher antioxidant properties were reported in *N. oleander* leaf extract. The ability of *Nerium oleander* to reduce and scavenge free radicals is one of its antioxidant activities, and this ability was linked to the total phenolic content discovered in each distinct extract in each experiment [Iran et al., 2012, Kumar et al., 2012]. *N. oleander* leaf, stem, and root extracts are potent free radical scavengers and an organic supply of strong antioxidants.

Anti-inflammatory properties

The ethanolic extracts of fresh flowers and dried leaves of *N. oleander* shown excellent anti-inflammatory effectiveness without endangering stomach health in a mouse model of carrageenan-induced hind paw edoema [Devi et al., 2019].

Antimicrobial activity

Novel medicinal molecules have been inspired by the plant since plant-derived medications have significantly improved human health. Bacterial strains including *B. subtilis* and *Nyctanthes arbortristis* were significantly affected by the ethanolic leaf extract. Oleander extracts have been shown to have antibacterial action against gram-negative bacteria. Researchers came to the conclusion that these chemicals, which lower the concentration of free radicals, are responsible for the antibacterial activity [Kumar et al., 2013].

Larvicidal activity

N. oleander aqueous leaf extract exhibited adulticidal and larvicidal actions on *Anopheles stephensi* in addition to its ovicidal and larvicidal properties [Roni et al., 2013]. The larval mortality of *Culex quinquefasciatus* was compared to crude hexane and aqueous *N. oleander* flower extracts [Raveen et al., 2014].

Anti-cancer cell inhibition properties

Ali and associates successfully employed oleander blossoms [Ali et al., 2009] extracted essential oil from oleander blossoms with success. When applied to Ehrlich Ascites Carcinoma (EAC) cell lines, it demonstrated efficacy. In human cancer cells, anvirzel and oleandrin have the ability to cause cell death, but not in mice. In one trial, oleandrin, According to the study's findings, PBI-05204 showed signs of a tumor response and oleandrin was well tolerated up to a dosage of 10.2 mg extract per day with little adverse effects [Pathak et al., 2000]. *N. oleander* extract can be applied

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topically without risk or toxicity; investigations have shown that skin absorption is negligible. This implies that it may be used at lower dosages to increase insect immunity and control pests without causing harm. The National Cancer Institute claims that oleandrin, a significant glycoside in *N. oleander*, has anticancer effects. Anvirzel™, a product of the University of Texas, has been shown to promote autophagy and death in cancer cells while sparing healthy cells. Moreover, it blocks NF-κB, a signal that encourages the proliferation and metastasis of cancer cells [ST et al., 2008, ST et al., 2009].

Cellular and humoral immune responses

Studies reveal the powerful immune-stimulating qualities of *N. oleander*. T and B lymphocytes, as well as the humoral and cell-mediated immune response, are stimulated by extracts. This improves particular subsets of mononuclear cells. Modest dosages of *N. oleander* considerably increased immunity in rabbits. On the other hand, a greater dose decreases the generation of antibodies, delays hypersensitive reactions, and slows down phagocytic activity [Schultz et al., 1982].

Poisonous nature

N. oleander has a variety of its constituents, some of which can be dangerous if consumed in excess, *N. oleander* has historically been thought to be a deadly plant, especially to animals. Lethal cardiac glycosides are present throughout the entire oleander plant. The highest concentration is found in seeds and roots. The water the plant was immersed in and its own smoke both have the potential to be toxic. The dangerous "cardiac glycosides" oleandrin and oleandrogenin are among these drugs; their window of therapeutic use is limited. Among the more serious adverse effects of oleander are mouth irritation, nausea, vomiting, emesis, stomach cramps, and diarrhea [Arai et al., 1992]. Rats were comparatively resistant to the effects of oleander "cardioactive glycosides," according to animal toxicology tests [Szabuniewicz et al., 1972]. More sensitivity has been shown in other mammals, including humans and dogs [Szabuniewicz et al., 1971; Hougen et al., 1979]. She consumed an unidentified oleander extract orally and rectally before she passed away, which resulted in higher amounts of oleandrin in her tissue at autopsy [Blum et al., 1983; Haynes et al., 1985]. Oleander's systemic hyperkalemia can worsen cardiac function, possibly leading to problems with conduction that start in the sinus or AV nodes and develop to PR interval lengthening and atrioventricular dissociation [Eddleston et al., 2000].

Mechanism of toxicity

Cardiac glycosides, which include nerium, folinerium, thevetin, adynerin, neriantin, digitoxigenin, and oleandrin, bind to the α-subunit of cardiac cells cytoplasmic membrane to block the Na⁺/K⁺ ATPase pump. This results in an increase in intracellular calcium levels and hyperkalemia [Dodd-Butera et al., 2005].

Signs of toxicity

It usually takes a few hours after consumption for clinical indications to manifest. Heart glycosides cause symptoms in the gastrointestinal system (localized diarrhea with blood, cramps, nausea, vomiting, and irritation of the mouth and digestive tract) as well as the cardiovascular system (dysrhythmias and ectopic beats, similar to digitoxin overdose). Dizziness, respiratory failure, unconsciousness, and even death could occur [Robert et al., 2020]. This study was unable to fully disclose all properties of *N. oleander*, including the lethal doses for different age groups of humans and different animal species, due to *N. oleander* poisoning and the tiny number of humans and animals that were affected by this plant's ingestion. Therefore, further experimental study is needed to address these issues [Farkhondeh et al., 2020].

Preventative actions

Medical intervention is necessary in cases of oleander plant poisoning or reactions involving humans or animals due to the rapid onset of symptoms. Atropine and isoproterenol are frequently effective treatments for conduction anomalies, and oral activated charcoal is a further option [Singh et al., 2013]. Contra-digoxin treating severe cardiac arrhythmias brought on by yellow oleander with fab fragments has shown to be successful. Anti-digoxin antibodies serve to stabilize sinus rhythm and are a quick treatment for bradycardia and hyperkalemia. The higher dosage



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needed for oleander toxicity in comparison to traditional digoxin toxicity, however, is explained by the digoxin-specific Fab's reduced affinity for nondigoxin cardiac glycosides. Some reported pharmacological properties of plant are shown in below table 1.

Future application of *N. oleander*

N. oleander is utilising cutting-edge extraction techniques and biotechnology research to develop a broad line of products that benefit from the unique and potent properties of *N. oleander*. Anti-aging skin creams are readily accessible on the cosmetics market nowadays. Many other products that are comparable to *N. oleander* these days, creams for spots, blemishes, skin repairs, and eyes are manufactured, among others. According to the American Cancer Society, "the effectiveness of oleander has not been proven," and "even a small amount of oleander can cause death." In HIV-positive patients with baseline CD4 values of less than 400, *N. oleander* is also effective in significantly increasing CD4 counts over a 60-day period. *N. oleander* aqueous extract is used in a novel anti-HIV therapy. *N. oleander* plant could be used in cancer and AIDS therapies in the future. *N. oleander* can be used as a potentially safer and more environment friendly way to manage pests like mosquitoes [Fonseka et al., 2002]

Recent Scientific Research

Recent studies have shed insight on *N. oleander* potential medical benefits while also emphasising the need for caution. The plant's cardiac glycosides have been studied for potential anti-cancer properties, particularly in relation to specific cancer cell types. Additionally, studies on oleandrin's potential as a neuroprotective and anti-inflammatory drug are still being conducted [Farkhondeh et al., 2020].

CONCLUSION

A botanical wonder that has fascinated people for millennia is *N. oleander*. It is an interesting topic to examine due to its remarkable look, long history, and variety of traditional therapeutic uses. When thinking about using the plant as medicine, extra caution must be used due to its toxicity, which cannot be ignored. Recent scientific research has provided some promising insights, but more study is needed to fully realize this wonderful but potentially dangerous plant's therapeutic potential. As we continue to explore the realm of natural cures, *N. oleander* serves as a reminder of the intricate interplay between beauty, danger, and healing in the plant kingdom.

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Author contribution

Equal contributions from all authors were made to the review effort.

Interests in conflicts Nil**REFERENCES**

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Table 1: List of reported pharmacological activities of *N. oleander* and their parts

S.N.	Parts of Plant	Extraction (Medium)	Model (In Vivo/ In Vitro)	Activity	Reference
1.	Fresh pulverized roots	95% EtOH	Disc diffusion method	Antibacterial activity	Huq M. Mostaqul et al., 1999
2.	Freshly ground leaves	Reconstituted lyophilized extract was chromatographed using water, methanol, acetone, and 2 N HCl in a sequential elution method on a Diaion HP-20 column	Effects on the growth of human tumor cell lines were assessed using a modified propidium iodide assay. conducted an acid phosphatase assay	Antitumor activity, Antiproliferative activity	Rashan Luay J. et al., 2011
3	Flowers	Petroleum ether (40 – 60 °C)	Pentylenetetrazol (PTZ)-induced convulsion test	Determination of anticonvulsant activity	Singhal KG, et al., 2011
4	Flowers	Petroleum ether, chloroform, ethyl acetate, methanol and water	Thiocyanate method	Antioxidant activity	Singhal Kumar Gaurav, et al., 2012
5	Flowers	50% Ethanol	Triton WR-1399-Induced Hyperlipidemia	Antihyperlipidemic activity	Gayathri V et al., 2013
6	Leaf	Aqueous extract	Well diffusion and disk methods	Antibacterial activity	S Hamon-Navard, et al., 2013
7	Leaf	Methanol	Method of DPPH	Antioxidant Activity	Siham Lakhmili, et al., 2014.
8	Shoots	Distillate	MTT assay	Antiviral Activity	Avci Oguzhan, et al., 2014
9.	Flowers	Hydro-distillation	Disk diffusion testing and Minimum inhibitory concentration (MIC)	Antibacterial activities	Derwich Elhoussine et al., 2010
10	Leaves	Ethanol extract using cold extraction method	Langendorff method	Cardiotonic effect	AdomeR. O., et al., 2003.
11	Leaves	The extraction was done with ethanol: water (1:1) for one hour at 60 °C	1. Measuring the levels of lactate and glucose in untreated and treated	Inhibition of glycolysis and cytotoxic activity	Calderón-Montaño José Manuel, et al.,



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		using an ultrasonic water bath equipment	cells 2. In-vitro MTT assay	against lung cancer cell	2013
12	Whole plant	Hot extract and cold extract	Plaque assay	Anti-poliovirus activity	Sanna Giuseppina, <i>et al.</i> , 2019
13	Leaves	Extracted with petroleum ether, chloroform and alcohol with the help of soxhlet apparatus	1. Anti inflammatory: Borgi and vogel Method 2. Antipyretic activity: Brevers yeast induced pyrexia	Anti inflammatory and Antipyretic activity	Kumar Senthil, <i>et al.</i> , 2010.
14	Flowers	Aqueous extract of flowers	Rotarod test	Activity of skeletal muscle relaxants	Tirumalasetti Jayasree, <i>et al.</i> , 2015
15	Flowers	Methylene chloride with methanol (1:1) extraction	Assay of Comet Diffusion plate technique	1. Level of DNA strand-break formation 2. Antibacterial and antifungal activity	Sawi M. El, <i>et al.</i> , 2010
16	Whole plant	<i>N. oleander</i> extract, Anvirzel™	After treatment, cell viability was assessed using the common Trypan blue dye-exclusion technique.	Effectiveness against human peripheral blood mononuclear cell HIV infection.	Singh Shailbala, <i>et al.</i> , 2013
17	Freshly collected leaves	Extracted with a hydroalcoholic solution (ethanol: water; 1:1)	In vivo studies with guinea pig	Arrhythmogenic activity	Botelho Ana Flávia Machado, <i>et al.</i> , 2017
18	Whole plant	Extracted with ethanol	Disc diffusion method	Antimicrobial activity	Makia Raghada S. A., <i>et al.</i> 2017
19	Whole plant	Aqueous extract	1. Agar-well diffusion method Mueller Hinton agar 2. cancer cell lines (L20B)	1. Activity against pathogenic bacteria 2. Cytotoxic effect on cancer cell line	Al- Obaidi Omar Hamad Shehab, <i>et al.</i> , 2014
20	Leaves and flowers	Soxhlet extracted with n-Hexane (Hex), dichloromethane (DCM) and methanol (Met),	1. RC50 value was measured as mg/mL. 2. Agar disc diffusion, agar dilution and determination of Minimum Inhibitory Concentration (MIC)	1. Antioxidant assay 2. Antibacterial assay 3. Cytotoxicity assay	Namian Pegah, <i>et al.</i> , 2013
21	Leaves	Aqueous and ethanol extractions	1. Cell lines used 2. Disc diffusion method 3. DPPH radicals	1. Cytotoxic 2. Antioxidant 3. Antimicrobial activities	Mouhcine Messaoudi, <i>et al.</i> , 2019
22	Leaves and	Methanol, ethanol,	Agar disc diffusion	Antimicrobial activity	Bameta Aika,



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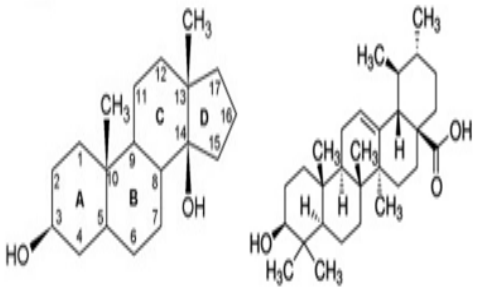
	stems	petroleum ether and chloroform	method		<i>et al.</i> , 2017
23	Leaves	Ethanol and aqueous extraction	Plate-hole diffusion assay	Antimicrobial activity	Aboud Anmar Saadi, <i>et al.</i> , 2014
24	Flowers	Ethanol Extract	Agar well diffusion method	Antimicrobial and Antifungal Activity	Magdum Dr. J. J., <i>et al.</i> , 2016
25	Flowers	Methanol Extract	Langendorff technique	Cardiotonic Effect	Tien Vung Nguyen, <i>et al.</i> , 2016.
26	Leaves	Aloe Vera based extract	Topical application	Wound healing potential	Akgun evcan Gul, <i>et al.</i> , 2017
27	Flowers	Mixture of ethanol, chloroform and water	agar diffusion method DPPH free radical scavenging	Antimicrobial and Antioxidant Effects	Saranya S <i>et al.</i> , 2017
28	Leaves and stems	Methanol extracts	Agar dilution method	Antibacterial activity	Abderrahim Leila Ait, <i>et al.</i> , 2017
29	Flowers	Methanol extract	Inhibition of albumin denaturation	Anti-Inflammatory Activity	Mary Dr.S.Jasmine, <i>et al.</i> , 2017.
30	Flowers	Methanol extract	in vitro activity-guided fractionation techniques	Anti-inflammatory Activity	Balkan İrem Atay, <i>et al.</i> , 2018
31	Leaves	Chloroform and Methanol	Well diffusion method	Antibacterial and Antifungal activity	Kiran Chaudhary, <i>et al.</i> , 2018
32	Flowers	Absolute ethanol	Ellman's method DPPH free radical scavenger activity	Cholinesterase (ChE) inhibitory activity Antioxidant activity	Balkan İrem Atay, <i>et al.</i> , 2018
33	Leaf, stem and root	Extracts made from aqueous, methanol, ethanol, chloroform, and acetone	Agar well diffusion method	Antifungal activity	Siddiqui, Bokhari N. A, <i>et al.</i> , 2016
34	Leaves	Aqueous extract by decoction method	Standard drug solution and different concentration of extracts were poured in different Petri dishes . Earthworms were used	Anthelmintic Activity	Kandagatla Swapna, <i>et al.</i> , 2019
35	Fresh dried roots	Aqueous-ethanol extract	Bioassay	CNS depressant activity	Tiwari Ghanshyam, <i>et al.</i> , 2020
36	Leaves	Hydrodistillation	Agar well diffusion method	Anti-bacterial activity	Almanaa Taghreed N <i>et al.</i> , 2021
37	Leaves	Alcoholic extract	Disk diffusion test onion root cells as a	Antibacterial Activity cellular toxic effect	Jaddoa Nihad Taha





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			model of the study		Mohammed, <i>et al.</i> , 2021
38	Flowers	Ethanol and Methanol (70% Concentration)	Agar well diffusion method	Antimicrobial activity	Dardona Ayman W Y, <i>et al.</i> , 2022.
39	Flowers and leaves	Hydro-ethanolic extracts extracted using a microwave	Spectrophotometric tests (DPPH, ABTS and FC) MTT Assay	Antioxidant activity Anticarcinogenic Activity	Ayouaz Siham, Koss-Mikołajczyk Izabela <i>et al.</i> , 2023

	
<p>Fig. 1 <i>N. oleander</i> L. plant</p>	<p>Fig. 2: The structure of Oleandrin and Ursolic acid [Rana et al., 2005].</p>





Challenges and Impact Analysis of NIPUN Bharat in Improving Foundational Literacy and Numeracy

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ABSTRACT

The purpose of this study is to assess NIPUN Bharat, the Indian program for proficiency in reading, comprehension, and numeracy, as well as its difficulties. NIPUN Bharat was introduced as a component of the National Education Policy 2020 with the goal of guaranteeing that all children acquire fundamental literacy and numeracy abilities by the conclusion of Grade 3. The study examines the program's effects and evaluates how well it works to enhance children's reading comprehension and math skills between the ages of three and nine. The study examines the various difficulties encountered in putting NIPUN Bharat into practice. It covers topics like the lack of resources, the digital divide, teacher preparation, diversity in language and culture, and the necessity of ongoing parental involvement. The study also explores the program's resistance to pedagogical adjustments and its flexibility to different educational situations. Through a thorough assessment, this study adds significant understanding of NIPUN Bharat's efficacy and makes suggestions for resolving the issues that arose. Policymakers, educators, and other stakeholders interested in improving foundational education in India are intended to benefit from the findings.

Keywords: NIPUN Bharat, FLN, Education, Training Programme.

INTRODUCTION

The NIPUN Bharat Scheme, recently introduced by the Ministry of Education, marks a significant initiative aimed at addressing the educational needs of children aged 3 to 9 years. Spearheading this effort, The National Initiative for Proficiency in Reading with Understanding and Numeracy was essentially introduced by Union Minister of

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Education Shri Ramesh Pokhriyal, or "Nishank." With a target date of 2026–2027, the overriding objective is to guarantee that every kid in the nation acquires fundamental literacy and numeracy by the end of Grade 3. This national purpose lays the groundwork for revolutionary changes in the country's school and higher education systems. It is an essential part of the National Education Policy (NEP) 2020. NEP 2020, which replaces the 34-year-old National Policy on Education (NPE) from 1986, focuses on important areas like giving children access to and retention during their formative years of education, developing high-quality and diverse learning materials for both students and teachers, and putting in place reliable progress tracking mechanisms to keep an eye on each student's learning outcomes. The launch of NIPUN Bharat aligns with the broader vision of NEP 2020, emphasizing the critical importance of foundational literacy and numeracy as building blocks for a comprehensive and inclusive educational framework in India. The initiative reflects a commitment to fostering a solid educational foundation for the country's youth, paving the way for a brighter and more equitable future.

What is the NIPUN Bharat Initiative's Complete Form

NIPUN Bharat Initiative stands for "National Initiative for Proficiency in Reading with Understanding and Numeracy Bharat Initiative." The NIPUN Bharat Initiative is a comprehensive national initiative that aims to improve the reading and numeracy proficiency of Indian pupils. The effort places special emphasis on ensuring that these fundamental abilities are mastered by the end of Grade 3, laying the groundwork for improved academic performance and increased opportunities for all children in the country.

Vision of NIPUN Bharat Initiative

NIPUN AXOM aims to establish a conducive atmosphere that guarantees the equitable attainment of fundamental literacy and numeracy skills. By the end of Grade 3, 2026–2027, all kids will have achieved the desired learning outcomes in reading, writing, and numeracy thanks to this.

NIPUN Bharat Mission Features

The NIPUN Bharat Mission encompasses a range of features that are strategically designed to foster foundational literacy and numeracy skills among students across India. These features are integral to the mission's comprehensive approach towards transforming the educational landscape.

Universal Learning Competencies

The goal of the NIPUN Bharat Mission is to guarantee that all people acquire the fundamentals of literacy and numeracy. The focus is on imparting essential competencies in reading with comprehension, proficient writing, and numerical skills.

End-of-Grade 3 Mastery

A key feature is the targeted timeline for skill mastery. The mission sets a clear objective that every child should achieve the desired learning competencies by the end of Grade 3. This time-bound approach adds urgency and specificity to the initiative.

Alignment with National Education Policy (NEP) 2020

NIPUN Bharat is in harmony with the transformative goals outlined in the National Education Policy of 2020. It aligns with the broader vision of restructuring and revitalizing the education system to meet the evolving needs of students.

Inclusive Learning Environment

The goal of the mission is to establish a welcoming atmosphere that meets the various needs of every student. It acknowledges how critical it is to accommodate differences in learning styles so that all children, regardless of background, may take advantage of the program.



**Lohans Kumar Kalyani****Strategic Planning for 2026-27**

NIPUN Bharat features a strategic planning horizon, setting the target year as 2026-27. This long-term vision allows for systematic implementation and assessment, fostering sustainable improvements in literacy and numeracy outcomes.

Technology Integration

The initiative acknowledges the role of technology in modern education. It incorporates elements of technology to enhance learning experiences, providing educators and students with digital resources and tools.

Progress Tracking Mechanism

NIPUN Bharat stresses the need of having a reliable system in place to monitor each child's development. Implementing effective monitoring and evaluation systems ensures that the initiative's goals are met and adjustments can be made as necessary.

Teacher Capacity Building

Recognizing the pivotal role of educators, NIPUN Bharat includes provisions for teacher training programs. Enhancing teacher capacity is seen as crucial to the success of the mission, ensuring that educators are well-equipped to facilitate improved learning outcomes.

In essence, NIPUN Bharat Mission's features encapsulate a holistic and forward-looking approach, addressing not only the immediate need for foundational literacy and numeracy but also considering the broader educational landscape and future learning requirements.

NIPUN Bharat Foundational Literacy and Numeracy (FLN)

The National Initiative for Proficiency in Reading with Understanding and Numeracy (NIPUN Bharat) is one of the most significant national missions focused on fundamental literacy and numeracy (FLN). FLN places a high value on a child's ability to read comprehension and solve simple math problems by the end of Class 3. Fundamental literacy and numeracy are highly valued in the National Education Policy (NEP) 2020, which is why it carefully combines two crucial elements: foundational language and literacy and foundational numeracy. The strong emphasis placed on FLN by NEP 2020 is in line with the overarching goal of education, which is to provide students with a solid grounding in language and math to support their future academic pursuits. The fundamental level synergistic integration of numerical aptitude and language competency is essential for supporting holistic educational development and equipping pupils for lifetime academic achievement.

Foundational Language and Literacy**(i). Focus Areas:**

- **Reading Comprehension:** Emphasis on developing the ability to understand and interpret written texts.
- **Writing Proficiency:** Building foundational writing skills, including grammar, vocabulary, and composition.

(ii). Key Components:

- **Phonics:** Understanding the relationship between sounds and letters.
- **Vocabulary Building:** Expanding the range of words known and understood.
- **Reading Fluency:** Developing the ability to read with speed, accuracy, and comprehension.
- **Comprehension Strategies:** Teaching methods to understand and interpret texts effectively.
- **Writing Skills:** Grasping fundamental writing techniques and expressing ideas coherently.

(iii). Teaching Approaches:

- **Storytelling:** Using narratives to enhance language skills and comprehension.
- **Phonics Instruction:** Systematic teaching of sound-letter relationships.
- **Reading Aloud:** Encouraging students to listen and comprehend spoken language.



**Lohans Kumar Kalyani****Foundational Numeracy****(i). Focus Areas:**

- **Basic Arithmetic:** proficiency in addition, subtraction, multiplication, and division—basic mathematical operations.
- **Number Sense:** Developing an intuitive understanding of numbers and their relationships.

(ii). Key Components:

- **Counting:** Learning to count numbers and understand their sequence.
- **Basic Operations:** Building skills in addition, subtraction, multiplication, and division.
- **Problem Solving:** Applying mathematical concepts to solve real-world problems.
- **Number Recognition:** Identifying and understanding the significance of different numbers.
- **Measurement:** Grasping basic concepts of measurement and comparison.

(iii). Teaching Approaches:

- **Hands-On Activities:** Engaging students in tangible, real-world math experiences.
- **Problem-Based Learning:** Encouraging students to solve problems using mathematical concepts.
- **Visual Aids:** Using visuals and manipulatives to aid understanding.

Comparative Insights

- **Interconnectedness:** While these areas seem distinct, they are interconnected. Proficiency in language can enhance mathematical understanding and vice versa.
- **Early Intervention:** Both literacy and numeracy skills are foundational and require early intervention for optimal development.
- **Holistic Approach:** Combining language and numeracy education creates a holistic learning environment, acknowledging the symbiotic relationship between these skills.
- **Individualized Learning:** Recognizing that students may have different learning styles and paces, educators tailor their approaches to cater to diverse needs in both language and numeracy education.

Remember, the effectiveness of these programs relies heavily on the integration of various teaching methodologies, continuous assessment, and the adaptability of educators to the unique needs of their students.

NIPUN Bharat Objective

- The Ministry of Education (MoE) oversees the NIPUN Bharat Mission, which is run by the Department of School Education and Literacy and has a designated Mission Director. The mission has a broad range of goals aimed at changing the educational system, including:
- **Inclusive Classroom Environment:** Create an inclusive learning environment by explicitly introducing home languages into the curriculum, connecting play, discovery, and activity-based pedagogies to children's everyday experiences.
- **Literacy Empowerment:** Give kids the opportunity to develop into enthusiastic, self-reliant, and involved writers and readers who possess long-lasting writing and reading abilities.
- **Numerical and Spatial Proficiency:** Develop children's capacity for reasoning in the areas of numbers, measurements, and shapes so they can solve problems on their own by improving their numeracy and spatial comprehension.
- **Quality Teaching Materials:** Make ensuring that excellent, culturally relevant teaching and learning resources are available and are used effectively in the mother tongue.
- **Continuous Capacity Building:** Make it a priority to continuously develop the competencies of educators, including head teachers, academic resource persons, and education administrators.
- **Stakeholder Engagement:** Actively collaborate with educators, parents, students, members of the community, and legislators to build a solid basis for lifelong learning.
- **Assessment Strategies:** Use a variety of assessment techniques to make sure that evaluation is done as part of and for learning, such as portfolios, group and collaborative projects, games, quizzes, role plays, oral presentations, and quick exams.



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- **Learning Progress Tracking:** Establish mechanisms to track the learning levels of all students, ensuring a dynamic and responsive approach to education.

NIPUN Bharat Mission Benefits

Children between the ages of 3 and 9 benefit greatly from the NIPUN Bharat Yojna's emphasis on helping them build the fundamental reading and numeracy skills that are necessary for their overall development.

- **Comprehensive Support:**By providing support to pupils from preschool through Class 3, the NIPUN Scheme guarantees a thorough approach to early childhood education.
- **Targeted Assistance for Classes 4 and 5:**Special provisions are established for children in Classes 4 and 5 who may not have the foundational skills as part of the NIPUN Bharat objective. To improve their academic performance, these children get committed peer assistance, tutoring, and additional learning resources.
- **Public and Private School Integration:**The mission aspires to achieve its objectives across both private and government-aided schools, intending to cover the entire educational spectrum by the year 2026-27.
- **Clear Learning Goals - "Lakshya":**The NIPUN Bharat Mission sets clear and measurable learning goals, encapsulated under the term "Lakshya," ensuring a focused and goal-oriented approach towards educational outcomes.

Level Learning Outcomes**(i). Balvatika:**

- **Identifies letters and their corresponding phonemes:** The foundational stage involves the recognition of letters and their corresponding sounds, setting the groundwork for language acquisition.
- **Capable of reading simple words with at least two or three alphabets:** Children at this level progress to reading basic words, typically consisting of 2 to 3 alphabets, enhancing their language skills.
- **Recognizes and reads numerals up to 10:** The introduction to numerals begins at this stage, with an emphasis on recognizing and reading numbers up to 10.
- **Sequences the numbers, items, shapes, and occurrences of events:** Developing a sense of order and sequence is fostered, encompassing the arrangement of numbers, objects, shapes, and understanding the occurrence of events in a sequence.

(ii). Grade 1:

- **Reads simple phrases in an age-appropriate unknown text that have at least four to five simple words:** Progressing from single words, students in Grade 1 advance to reading small sentences, typically composed of 4-5 simple words, in texts unfamiliar to them.
- **Read and write numbers up to 99:** Numeric literacy expands, enabling students to read and write numbers up to 99, enhancing their mathematical capabilities.
- **Perform simple addition and subtraction:** Basic arithmetic operations, such as addition and subtraction, become part of the learning outcomes at this stage.

(iii). Grade 2:

- **Read with meaning:** The focus intensifies on reading comprehension, encouraging students to read with a deeper understanding of the content.
- **45 – 60 words per minute:** Reading fluency is emphasized, with the target of achieving a reading speed of 45-60 words per minute.
- **Read and write numbers up to 99:** Numerical proficiency continues to develop, with students maintaining the ability to read and write numbers up to 99.
- **Subtract numbers up to 99:** The scope of mathematical operations expands, incorporating subtraction of numbers up to 99.

(iv). Grade 3:

- **Read at least 60 words per minute meaningfully:** Reading fluency is further refined, with an increased target of reading at least 60 words per minute.
- **Write and read the digits up to 99:** Numeric literacy remains a focus, with continued proficiency in reading and writing numbers up to 99.



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- **Resolve basic multiplication issues:** Introduction to multiplication is initiated, with students expected to solve simple multiplication problems, laying the foundation for more advanced mathematical concepts.

Implementation of NIPUN Bharat

- The implementation of NIPUN Bharat would be under the purview of the Department of School Education and Literacy. A comprehensive five-tier implementation system operating at the national, state, district, block, and school levels will be in place for all States and Union Territories. This project is funded centrally as part of the Samagra Shiksha initiative.
- Three previous programmes, Teacher Education (TE), RMSA, and SSA, were combined into the new 'Samagra Shiksha' programme. This program's main objective is to handle schooling from preschool through Class XII in an all-encompassing manner.
- NCERT is assisting NISHTHA in developing a specific package for FLN under the auspices of NIPUN Bharat. An ambitious initiative to train almost 25 lakh instructors are using FLN to educate pre-primary through primary classes.
- NISHTHA is a vital capacity-building program that aims to improve school education quality by providing integrated teacher training. The training objectives are outlined in a step-by-step manner that includes pre-primary or balvatika sessions, guaranteeing a methodical approach to learning at every level.

Expected Outcomes OF NIPUN

The anticipated outcomes of NIPUN encapsulate a spectrum of transformative impacts on the educational landscape, emphasizing foundational skills and holistic development.

- **Retention and Transition:** It is hoped that foundational skills would act as a solid base, reducing the number of students dropping out and promoting a smooth transition from elementary to upper primary and secondary education.
- **Quality Enhancement:** The implementation of activity-based learning strategies coupled with a conducive learning environment is poised to elevate the overall quality of education, providing a more enriching and immersive experience for students.
- **Innovative Pedagogies:** The incorporation of innovative pedagogical approaches, including toy-based and experiential learning, is set to infuse joy and engagement into classroom transactions, making learning a vibrant and participatory endeavor.
- **Empowered Teachers:** Through intensive capacity-building initiatives, teachers are expected to be empowered, granting them greater autonomy in selecting and implementing pedagogical methodologies tailored to the unique needs of their students.
- **Holistic Child Development:** NIPUN lays a strong focus on the holistic development of children, covering a wide range of areas including literacy and numeracy proficiency, life skills, physical and motor abilities, socio-emotional health, and cognitive development. A thorough Holistic Progress Card will represent these interrelated aspects.
- **Accelerated Learning Trajectory:** Enabling children to achieve a steeper learning trajectory is anticipated to yield positive impacts on later life outcomes and employability, setting the stage for lifelong success.
- **Equitable Access:** Given the near-universal attendance of early grades, the strategic focus on this stage is poised to disproportionately benefit socio-economically disadvantaged groups, ensuring equitable and inclusive access to quality education.

Effectiveness of Nipun Bharat Yojana in the present Education System

The NIPUN Bharat Yojana holds significant importance in the present education system, offering a multifaceted approach to address crucial aspects and challenges. Here are some key points highlighting its usefulness:

- **Foundational Skills Enhancement:** NIPUN Bharat concentrates on teaching kids between the ages of three and nine fundamental reading and numeracy abilities. By targeting these formative years, the scheme aims to equip students with essential skills that lay the groundwork for future academic success.



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- **Early Intervention for Lifelong Learning:** Early childhood is a critical phase for cognitive development. NIPUN Bharat's emphasis on foundational skills ensures early intervention, setting children on a trajectory for lifelong learning and enabling them to grasp more advanced concepts as they progress through the education system.
- **Reducing Dropout Rates:** By enhancing foundational skills, NIPUN Bharat seeks to reduce dropout rates. Strong foundational literacy and numeracy skills contribute to better comprehension and engagement, making it more likely for students to remain in school and pursue higher education.
- **Inclusive Education:** Through the use of a variety of pedagogies, such as play-based and activity-based learning, the program seeks to establish an inclusive learning environment in the classroom. Children from different backgrounds and skill levels can actively engage in the learning process thanks to this inclusion.
- **Quality Enhancement through Holistic Development:** NIPUN Bharat goes beyond academic skills and emphasizes holistic development, including physical, emotional, and cognitive aspects. This holistic approach contributes to the overall quality of education, nurturing well-rounded individuals.
- **Empowering Teachers:** The scheme recognizes the pivotal role of teachers in achieving its objectives. Capacity-building initiatives for teachers ensure they are well-equipped to implement effective teaching methodologies, creating a positive impact on students' learning experiences.
- **Innovative Pedagogies for Engagement:** NIPUN Bharat promotes cutting-edge pedagogies to make learning more interesting and pleasurable, like toy-based and experiential learning. This not only enhances educational outcomes but also fosters a love for learning.
- **Assessment and Tracking:** The scheme places importance on continuous assessment through various methods, including portfolios, collaborative work, and quizzes. This allows educators to track the learning levels of students and tailor interventions accordingly.
- **Socio-economic Inclusivity:** By focusing on foundational literacy and numeracy, NIPUN Bharat aims to bridge socio-economic disparities in education. It ensures that children, especially those from disadvantaged backgrounds, have equal access to quality education. NIPUN Bharat Yojana emerges as a comprehensive initiative designed to fortify the foundations of education, enhance learning experiences, and contribute to a more inclusive and equitable educational landscape in India.

Challenges Of Nipun Bharat Yojana

While the NIPUN Bharat Yojana holds promising objectives for improving foundational literacy and numeracy in India's education system, it also faces certain challenges. Here are some key challenges associated with the implementation of NIPUN Bharat:

- **Infrastructure and Resource Constraints:** Many schools, especially in rural areas, face challenges related to inadequate infrastructure, including classrooms, teaching aids, and learning materials. Insufficient resources can hinder effective implementation of NIPUN Bharat's initiatives.
- **Teacher Training and Capacity Building:** The success of NIPUN Bharat relies heavily on the effectiveness of teacher training programs. Ensuring that teachers are adequately trained and have the necessary skills to implement innovative pedagogies can be a substantial challenge, particularly in remote areas.
- **Diversity in Languages and Cultures:** India is a linguistically diverse country with various regional languages and cultures. Adapting teaching materials and methods to cater to this diversity poses a significant challenge. Localized content is essential to ensure that children can relate to the learning materials.
- **Monitoring and Evaluation:** Continuous assessment and tracking of student progress are fundamental to the NIPUN Bharat mission. However, establishing robust monitoring and evaluation mechanisms at various levels, from national to local, can be complex and resource-intensive.
- **Parental Engagement and Awareness:** Engaging parents in the educational journey of their children is crucial. However, in many cases, there may be a lack of awareness or involvement from parents, especially in marginalized communities. Educating and involving parents becomes a challenge.
- **Digital Divide:** With an increasing emphasis on technology-based learning, the digital divide poses a challenge. Not all schools and students have access to digital devices and the internet, leading to disparities in the implementation of online or technology-driven educational programs.



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- **Resistance to Change:** The adoption of novel pedagogical approaches and instructional techniques may encounter opposition from established educational establishments. It might be difficult to persuade parents, administrators, and educators to accept change.
- **Socio-economic Disparities:** Socio-economic disparities among students can impact the effectiveness of NIPUN Bharat. Children from disadvantaged backgrounds may face additional hurdles such as lack of proper nutrition, health issues, and home environments that are not conducive to learning.
- **Alignment with Existing Curricula:** Aligning NIPUN Bharat initiatives with existing curricula and examination systems can be a challenge. Ensuring that the foundational literacy and numeracy skills align seamlessly with the broader educational framework requires careful planning.
- **Long-term Sustainability:** The sustainability of the initiatives under NIPUN Bharat over the long term is a critical challenge. This involves maintaining the momentum of the program, securing continued funding, and adapting strategies to evolving educational landscapes.

Addressing these challenges will be essential for the successful and sustained implementation of NIPUN Bharat, ensuring that its objectives contribute significantly to improving foundational literacy and numeracy levels across the country.

CONCLUSION

The NIPUN Bharat evaluation highlights the organization's admirable initiatives to improve young students' basic literacy and numeracy abilities in India. The program is a positive step toward achieving the learning goals outlined in the National Education Policy 2020, but there have been challenges encountered along the route that require acknowledgment and resolution. The ability of NIPUN Bharat to lower dropout rates, enhance the transition from elementary to upper primary stages, and establish an engaging learning environment through creative pedagogies is clear evidence of its efficacy. Intense teacher capacity building and a focus on holistic child development all help to improve the educational system as a whole. The report also identifies a number of important obstacles, such as the lack of resources, the digital divide, the diversity of linguistic and cultural environments, and the reluctance to pedagogical innovations. To ensure NIPUN Bharat's long-term success, these issues must be resolved. In order for the project to succeed going ahead, legislators, educators, and stakeholders must work together to improve implementation tactics, supply required resources, and create a positive atmosphere. By doing this, it will be possible for NIPUN Bharat to continue exerting a major effect on the Indian educational system and to ensure that every kid has equitable access to a foundational education of the highest caliber.

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Promote Visual Support to Enhance Communicative Skills in Children with Autism

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ABSTRACT

Children diagnosed with autism spectrum disorders (ASD) have difficulties communicating, interacting with others, and using language. They rarely respond to parents and carers and typically avoid making eye contact. Other disabled youngsters use gestures or nonverbal communication to make up for their lack of language and communication skills. It is rare for kids with ASD to speak out of the blue or have discussions with other kids or adults. While some kids with ASD engage in peer connections on their own, others only react; they don't start conversations. The study's objective is to ascertain how visual aids affect autistic children's social, linguistic, and functional capacities. The current study included a total of thirty individuals, ranging in age from two to nine years old (15 in the experimental group and 15 in the control group). The method used to evaluate functional abilities, while the Indian scale for assessment of autism is used to diagnose autism. notable progress in functional abilities about occupational therapy's visual supports. According to research analysis, visual strategies are quite beneficial for helping children between the ages of 5 and 11 enhance their communication skills. The results of this study lend credence to the idea that the use of visual aids enhances comprehension, boosts engagement, and ultimately leads to more successful communication. The pre-and post-test results for the experimental and control groups were examined. The results are examined in light of important factors that could influence how successful a treatment is in the future for both practice and research. For children with autism, occupational therapy appears to compound the positive effects of both therapeutic modifications by enabling them to be self-sufficient in performing all activities of daily living.

Keywords: Autism spectrum disorder, Activities scale for kids, children, visual aids.





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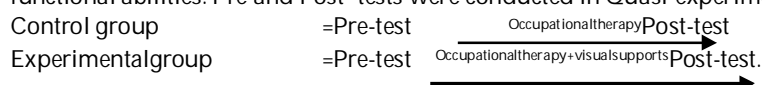
INTRODUCTION

Autism Spectrum Disorder (ASD) is frequently associated with language and communication issues, such as difficulties interpreting and producing language. Complex language abilities are needed for conversational speech. It can be challenging for kids with ASD to start and continue a discussion, to take turns in a conversation, and to keep up that interaction. Before starting kindergarten, young children must understand how to end one activity and start another promptly. The effectiveness of using a photo figure cue package to help a young kid with autism successfully transition between daily routines in three distinct school environments, [1]. The article discusses the implications of teaching young infants a range of activities with photo-figure cue packages.. According to, [2] there was a significant increase in the number of grooming behaviors performed by all individuals during treatment. During follow-up, there was only a little decline in behavior completion; this is explained by the pictorial cues, which are frequent stimuli used in other maintenance programming processes to help mentally retarded people develop independent living skills. Baseline-1 and Baseline-2 sessions were carried out, [3]. They removed the schedules when these sessions were over. The children were able to complete a task without supervision or suggestions once the visual supports were removed, therefore it can be said that using visual supports to help autistic pupils transition is successful. According to, [4] autism is a neuro developmental condition that affects socialization and communication and is typified by stereotypical behavior. Globally, autism has advanced in rehabilitation services over the last ten years, and research suggests that the number of cases of autism diagnosis has increased by 50% to 2000%. [5] used the ISAA as a diagnostic tool for autism severity in 400 children who were referred for possible autism and ranged in age from 5 to 15. Results indicated that 78.2% of the 400 children who were chosen to have autism had mild autism, 10.8% had moderate autism, and 11.0% had severe autism.

According to WHOQOL-BREF, parents of children with autism exhibited considerable impairment in all four categories (physical, psychological, social, and environmental) when compared to parents of other children, [6]. The mean summary score for normal kids was 93.12, which is considerably higher than the mean score for kids with minor disabilities. In summary, the ASKp score determination for children without musculoskeletal problems offers valuable insights that can support the ASKp's application in clinical and research contexts to evaluate a child's functional level and track any alterations, [7]. A correlation of 0.81 ($p < 0.0001$) with parent-reported childhood showed the validity of the ASK, and Rasch analysis verified that all questions measured the same construct and validated summary score, [8]. [9], describe three photo-type systems that use mobile personal devices, big group displays, and personal recording technologies to address these design issues. Using visual supports for students with autism in inclusive physical education; analyzing the impact of visual supports on individuals with autism who behave in time-on-task and time-off-task manners in inclusive physical education; and analyzing the impact of visual supports on individuals with autism who behave in assisted task-related ways in inclusive physical education, [10]. After receiving 14 one-on-one sessions, the experimental group showed progress. It is determined that youngsters between the ages of 5 and 11 can develop their communication abilities more effectively by using visual tactics, [11]. Three autistic children were used in the testing, and the results showed that all three of them satisfied the PECS learning requirements and should consequently exhibit improved social communication and behavior, [12]. [13], is to find out how well three low-functioning autistic children may learn daily life tasks using visual self-management. The findings demonstrated that autistic children could effectively utilize pictures to control their behavior when a treatment provider was not present, generalize their behavior to different tasks and environments, and retain their behavior throughout follow-up.

MATERIALS AND METHODS

The objective of the study is to ascertain how visual support affects autistic children's social, communicative, and functional abilities. Pre and Post- tests were conducted in Quasi-experimental design.



**Jegadeesan and Nagalakshmi****MATERIAL SETTINGS**

In total, thirty patients were recruited for this study. They were diagnosed with mild to moderate autism using the ISAA, and they ranged in age from two to nine years. The thirty patients were split into two groups—a control group and an experimental group—and all thirty of them showed delays in social, communicative, and functional skills. Fifteen individuals were drawn from the Occupational Therapy Foundation clinic in Trichunogode for the control group, while the fifteen subjects were drawn for the experimental group from Sri Sarvavidhya Multispeciality Therapy Centre in Erode. The Activities scale for kids is used to quantify social, communicative, and functional skills. The experimental group received visual assistance therapy, while the control group merely received interaction. The therapy was administered for three months, during which time it was increased to one hour on six days each week. The patients in the experimental group had a total of 34 treatment sessions, which were then broken down into 6 sessions: 1–5, 6–10, 11–15, 16–20, 21–25, 26–30, and 31–34. The experimental group of 15 students was divided into two subgroups, consisting of 8 students in one group and 7 students in another. Each group received three days of therapy for its respective subgroup. Pre-test results were obtained using ASK at both groups' entry-level, and post-test results were obtained using ASK once more following the treatment of visual support.

Selection criteria

The selection criteria were divided into two groups: inclusion and exclusion. The study's participant pool consisted of kids with autism who were between the ages of 2 and 9, as per the inclusion criteria. Kids who struggle with communication, socialization, and function. Both males and females were chosen for this study. Children classified as having severe autism (ISAA score > 153). The upper age restriction for the exclusion criteria is nine years old. Based on these criteria, children who had a documented medical history of any severe illness and those who had physical dysfunction were chosen. Mental retardation, Asperger's syndrome, Rett's syndrome, and other associated disorders are excluded by an exclusion criterion.

Equipment

The Activities Scale for Kids (ASK) scales were used for the assessment. The Activities Scale for Kids (ASK), a self-reported indicator of physical impairment in children, shows good reliability (ICC=0.97).

Validity: Based on the premise that the genuine correlation was roughly 0.8 alpha = 0.05, beta = 0.20, the sample size computed for the comparison of the Activities Scale for Kids (ASK) and Childhood Assessment Questionnaire (CHAQ) was based on a correlation of at least 0.6. According to this estimate, 40 out of the 200 children who were gathered for the Rasch analysis were included in the assessment of construct validity, even though baseline data from all 200 children were used.

RESULTS AND DISCUSSIONS**Data Analysis and Interpretation**

The results of both pre and post-tests for the experimental and control groups are displayed in the figures and tables given below, with the significant differences highlighted. The pre-test results of the experimental and control groups' ASK performance are evaluated in [Table 1 and Figure 1]. The ASK performance mean values, according to the unpaired t-test, are 19.733 and the 19.667, t value is 0.03309 and the p-value is 0.9738, in that order. It demonstrates that there is no discernible change in pre-test values for ASK performance between the experimental and control groups. [Table 2 and Figure 2] compare the experimental and control groups' pre- and post-test ASK capacity values. The results of the unpaired t-test reveal that the experimental and control groups' pre-test ASK capacity values do not significantly differ from one another (mean values: 34.133 and 33.333, respectively; t value: 0.3566; p-value: 0.7241). The effectiveness of using a photofigure cue package to help a young child with autism successfully transition between daily routines in three distinct school environments was investigated. The effectiveness of the intervention was assessed using a multiple baseline across contexts methodology. There is a discussion of the implications of teaching young children a range of activities with photofigure cue packages. ASK performance post-test data for the experimental and control groups are compared in [Table 3 and Figure 3]. With a mean value of



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70.800 and 20.666, respectively, t values of 3.061, and a p-value of 0.0048, the unpaired t-test reveals a very significant difference between the experimental and control groups' post-test ASK performance scores. [Table 4 and Figure 4] present a comparison of the ASK capacity post-test values between the experimental and control groups. The unpaired t-test reveals a very significant result with a mean value of 72.400 and 34.600, respectively, a t-value of 6.039, and a p-value of 0.0001. The comparison of the control group's pre- and post-test values for ASK performance is shown in [Table 5 and Figure 5], with mean values of 19.667 and 20.666, respectively, t value of 0.5903, and p-value of $p > 0.05$. It demonstrates that there are no notable differences between the groups. The control group's pre- and post-test ASK capacity values are compared in [Table 6 and Figure 6], with mean values of 33.333 and 34.600, respectively. A t value of 0.6102 and a p value of $p > 0.05$ indicate that there is no significant difference. The experimental group's comparative and post-test results for ASK performance are displayed in [Table 7 and Figure 7]. The paired t-test indicates that the mean values are 19.733 and 70.800, the t-values are 14.697, and the p-value is 0.0167, all of which are highly significant. The findings demonstrated that autistic children could effectively utilize pictures to control their behavior when a treatment provider was not present, generalize their behavior to different tasks and environments, and retain their behavior throughout follow-up. [Table 8 and Figure 8] compare the experimental group's pre- and post-test ASK capacity levels. The mean values of 34.133 and 72.400, as well as the t-value of 10.313 and p-value of 0.0077, indicate that the paired t-test is very significant. It was carried out using thirty kids from Mumbai's special education schools. Visual aids included manual signs, objects, images, and symbols. After receiving 14 one-on-one sessions, the experimental group showed progress. It is established that children between the ages of 5 and 11 benefit greatly from visual tactics in the development of their communication skills. The findings of this study support and strengthen the theory that using visual aids improves understanding, increases participation, and eventually results in more effective communication.

CONCLUSION

The study's findings indicate that, when compared to the control group, the experimental group of autistic children who received visual assistance improved more in social, communicative, and functional skills. This suggests that providing visual assistance to autistic youngsters was a useful strategy for bringing about functional changes in them. Combining a visual support program with occupational Therapy seems to enhance the benefits of both therapeutic changes in children with Autism, which supports them to be independent in doing all their daily tasks.

LIMITATIONS

Convenient sampling was used to enlist participants, and while the researcher used observation and analysis to evaluate the behavioral features, part of the study relied on the subjective input provided by the parents.

ABBREVIATIONS

ASK – Active Scale for Kids
ASD – Autism Spectrum Disorder
PECS – Picture Exchange Communication Systems
ISAA – Indian Scale for Assessment of Autism
CHAQ – Childhood Assessment Questionnaire

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Table 1: Comparison of pre-test values of experimental and control groups of ASK performance

Group	Factor	Test	Mean	S.D	t value	P value
Experimental	ASK Performance	Pre	19.733	6.112	0.03309	p>0.05
Control		Pre	19.667	4.850		

Table 2: Comparison of pre-test values of experimental and control groups of ASK Capability

GROUP	Factor	TEST	MEAN	S.D	"t"Value	Pvalue
Experimental	ASK Capability	Pre	34.133	6.105	0.3566	p>0.05
Control		Pre	33.333	6.184		

Table 3: Comparison of post-test values of experimental and control groups of ASK performance.

GROUP	Factor	TEST	MEAN	S.D	value	P value
Experimental	ASK performance	Post	70.800	11.989	3.061	p<0.05
Control		Post	20.666	8.016		

Table 4: Comparison of post-test values of experimental and control groups of ASK Capability.

GROUP	Factor	TEST	MEAN	S.D	value	P value
Experimental	ASK Capability	Post	72.400	13.010	6.039	P<0.05
Control		Post	34.600	9.148		

Table 5: Comparison of pre and post-test values of a control group for ASK Performance.

GROUP	Factor	TEST	MEAN	S.D	value	P value
Control	ASK Capability	Control Pre	19.667	4.850	0.5903	P<0.05
		Control Post	20.666	4.419		





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Table6: Comparison of pre and post-values of a control group for ASK capability.

GROUP	FACTOR	TEST	MEAN	S.D	t value	PValue
CONTROL	ASK Capability	Controlpre	33.333	6.184	0.6102	p>0.05
		Controlpost	34.600	5.138		

Table 7: Comparison of pre and post-test values of the experimental group for ASK performance.

GROUP	Factor	TEST	MEAN	S.D	value	P value
Experimental	ASK performance	Pre	19.733	6.112	14.697	p<0.05
Control		Post	70.800	11.989		

Table 8: Comparison of pre and post-test values of the Experimental group for ASK Capability.

GROUP	Factor	TEST	MEAN	S.D	value	P value
Experimental	ASK performance	Pre	34.133	6.105	10.313	p<0.05
Control		Post	72.400	13.010		

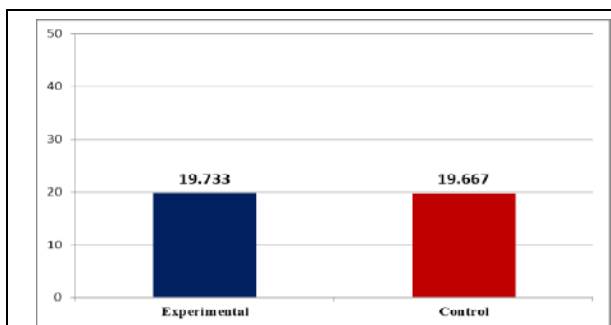


Figure 1: Comparison of Ask Performance

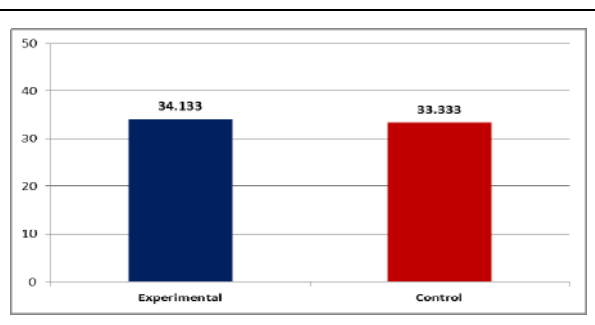


Figure 2: Comparison of Ask Capability Pre-Test Values of Experimental and Control Group

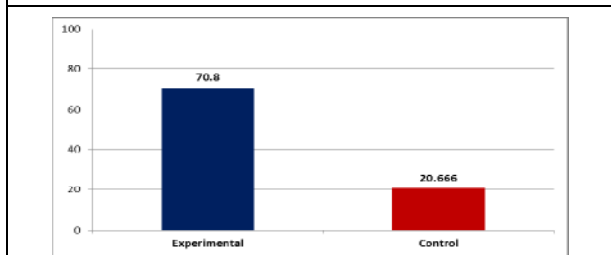


Figure 3: Comparison of Post Test Values of Experimental and Control Group of Ask Performance

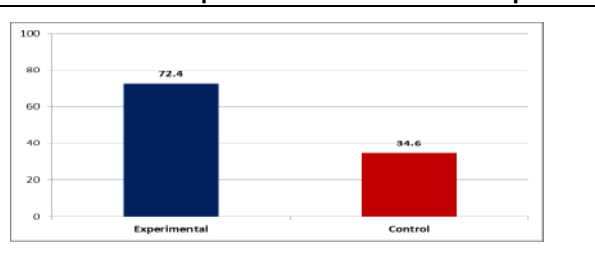


Figure 4: Comparison of Post Test Values of Experimental and Control Groups of Ask Capability





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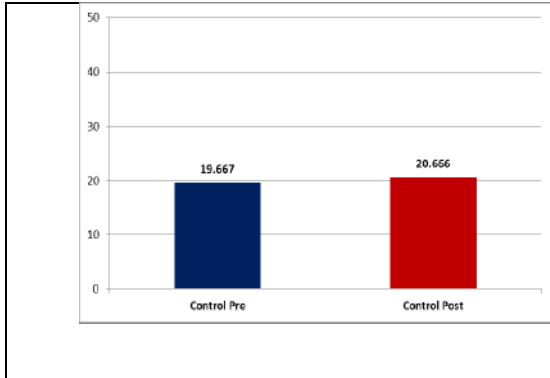


Figure 5: Comparison of Pre and Post Test Values of the Control Group For Ask Performance

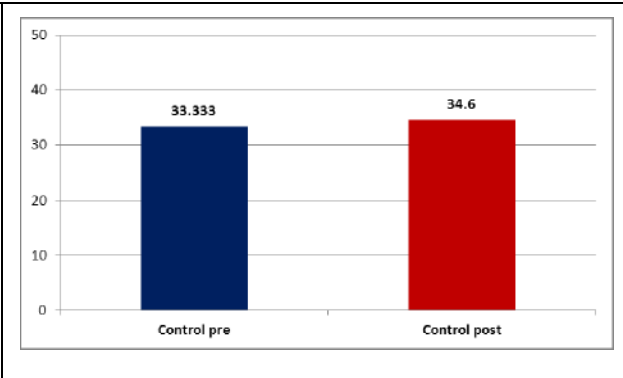


Figure 6: Comparison of Pre and Post Test Values of the Control Group For Ask Capability

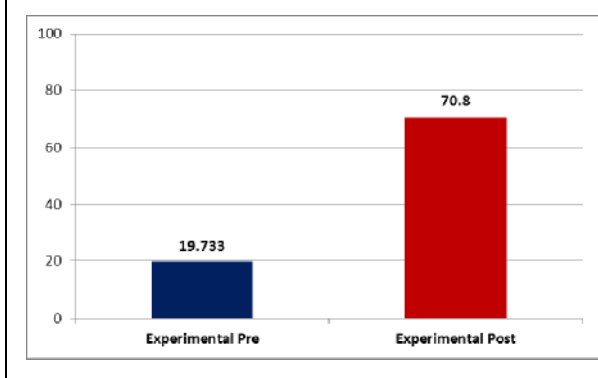


Figure 7: Comparison of Pre and Post Test Values of Experimental Group

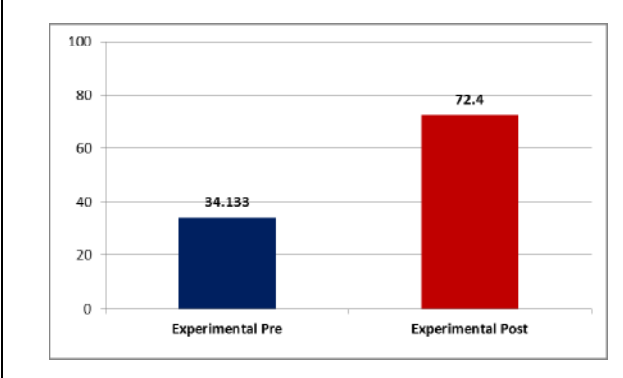


Figure 8: Comparison of Ask Capability Pre-Test Values of Experimental Group





Role of Salicylic Acid and Humic Acid In improving the Growth, Biomass and Pigment Composition in *Sesamum indicum* L. (Tmv-4) Variety Grown under NaCl Stress

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ABSTRACT

Soil salinity has become a significant environmental concern due to a growing population and limited arable land. Salt stress on plants has three main effects: It diminishes water potential, disrupts ion balance and homeostasis, and induces toxicity. These alterations in water status initially hinder growth and ultimately limit plant productivity. In this regard, the experimental pot study was carried out to study the impact of salt stress and plant growth regulators salicylic acid and humic acid in mitigating the salinity impact on the *Sesamum indicum* L. (TMV-4) Variety. The plants were treated as, Control, NaCl (100mM), NaCl (100mM) + salicylic acid (1mM), NaCl (100mM) + Humic acid (500mg/L), Humic Acid (500mg/L) and Salicylic acid (1mM/L). The NaCl treatment was given by soil drenching and plant growth regulators were applied by foliar. Plants were collected randomly for experimental study on the 35th, 45th, and 55th, Days after sowing, to analyze the growth parameters and biomass content and estimate pigment composition in *Sesamum indicum* L. NaCl stress caused the reduced effect on root length, shoot length, biomass content, and leaf area of *Sesamum indicum* L. plants, the pigment composition was also declined due to NaCl stress effect. In contrast, the plants treated with salicylic acid and humic acid ameliorate the effects of salt stress and enhance the growth parameters biomass content and pigment composition in the *Sesamum indicum* plants. Thus, it can be concluded that these two plant growth regulators can be used to mitigate the salinity stress in gingelly plants.

Keywords: Salicylic acid, humic acid, salt stress, gingelly, NaCl.



**Silambarasan and Rajan****INTRODUCTION**

Salinity represents a significant environmental constraint that restricts plant growth and overall productivity. Elevated salinity levels exert adverse effects on plants, manifesting as plant mortality or reduced productivity. Numerous plant species have evolved adaptive mechanisms to counteract the negative impact of salinity, either by preventing salt entry into their cells or by developing tolerance mechanisms to cope with salt accumulation within their cellular environment. [1]. High concentrations of sodium (Na⁺) and chloride ions (Cl⁻) are the primary contributors to salt stress. This stress condition has three main effects as follows: - it diminishes water potential, disrupts ion balance and homeostasis, and induces toxicity. These alterations in water status initially hinder growth and ultimately limit plant productivity. Salt stress encompasses both osmotic and ionic stress components. [2,3,] Salt stress prompts a rapid reduction in leaf surface expansion rates, eventually halting expansion as salt concentration increases. Furthermore, it leads to a substantial decrease in the fresh and dry weights of leaves, stems, and roots. [4]. As salinity levels rise, the water potential and osmotic potential of plants become increasingly negative, while turgor pressure increases. [5] Under salt stress, chlorophyll and total carotenoid levels in leaves typically decrease, leading to chlorosis and eventual shedding of the oldest leaves over prolonged exposure to salt stress [6]. *Sesamum indicum* L. commonly known as sesame, is a significant oilseed crop with economic importance.

It is extensively grown across various regions globally, including but not limited to India, China, Thailand, Mexico, Guatemala, Afghanistan, Pakistan, Bangladesh, Indonesia, Sri Lanka, Saudi Arabia, and Turkey[7]. Sesame oil comprises sesamin and sesaminol lignans within its non-glycerol fraction, and these components are acknowledged for their crucial roles in enhancing oxidative stability and antioxidative activity[8]. Salicylic acid has been demonstrated to have a pivotal function in activating defense mechanisms against various abiotic stresses, such as salinity and osmotic stress. Several research investigations have indicated that the external application of salicylic acid (SA) can mitigate the toxic effects caused by salinity stress in numerous plant species[9,10]. Exogenous SA treatment induces the expression of pathogenesis-related (PR) genes, including PR1, PR2, and PR5 [11]. Humic acid, found in organic humus, is not classified as a fertilizer but rather as a plant bio-stimulant. Its application leads to significant enhancements in soil and plant characteristics, thereby effectively enhancing plant growth and productivity [12]. Humic acid possesses the capacity to safeguard plants from both abiotic and biotic stresses while also fostering their growth and development. This stimulation contributes to enhanced yields and agricultural production. [13]. The beneficial impacts of humic acid have been associated with enhancements in soil characteristics, including aeration, aggregation, water retention capacity, ion availability, and transport mechanisms. These improvements facilitate more efficient uptake of nutrients and water by plants, as well as increased accumulation of photosynthates, particularly in conditions of water stress[14,15].

MATERIALS AND METHODS

Sesamum indicum L. specifically the TMV-4 variety was purchased from Tamil Nadu Agricultural University in Coimbatore (TNAU), Tamil Nadu, India. The chemical regulators Humic acid, salicylic acid, and the analytical reagent sodium chloride (NaCl) were purchased from Sisco Research Laboratories [SRL] based in Chennai India.

Experimental design

An experimental study on the plant *Sesamum indicum* L. was conducted at the Botanical Garden situated within the Department of Botany at Annamalai University, located in Chidambaram, Tamil Nadu. The geographical coordinates of the experimental site were recorded as 11°23'23.1"N and 79°43'05.3"E. Prior to sowing, the healthy seeds underwent surface sterilization utilizing a 0.2% mercuric chloride solution for 2 minutes, followed by extensive rinsing with sterile double-distilled water to ensure sterility. The seeds of the TMV-4 variety of *Sesamum indicum* were then sown in a total of 90 pots, which were further categorized into six distinct groups. Each group, comprising ten replicates, received a single application of mixed fertilizer combined with manure, with the soil composition maintained at a ratio of red soil, sand, and farmyard manure in a 1:1:1 proportion. Various treatments were





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administered to the plants. Control, (without treatment) NaCl (100mM), NaCl (100mM) + salicylic acid (1mM), NaCl (100mM) + Humic acid (500mg/L), Humic Acid (500mg/L) and Salicylic acid (1mM/L). The salinity levels within the pots were meticulously monitored at regular intervals by assessing soil samples from each pot using an Electrical Conductivity Meter. Plant specimens were harvested at specific time points (i.e., at the 35th, 45th, and 55th days after sowing [DAS] to conduct morphological and chlorophyll pigment analyses, thereby evaluating the impact of the different treatments on plant growth and physiological parameters.

Root length

The collected plant roots are thoroughly washed with tap water and waited for 15 minutes for drying the moisture. To calculate the root length by measuring below the point of root-shoot transition to fibrous root and the lengths of lateral roots were taken as total root length. The root lengths were expressed in cm plant⁻¹.

Shoot length

The length between the shoot tip and the point of the root stem transition region was taken as shoot length. The stem lengths are expressed in cm plant⁻¹.

Fresh weight

The plant samples that are collected, roots, and shoots were thoroughly washed with tap water and tissue paper was used to remove the excess moisture. The root and shoot fresh weights were taken by using an electronic balance (Model - XK3190-A7M) and the values were recorded and expressed in gm plant⁻¹.

Dry weight

After taking fresh weight, the plants were dried at 60°C in a hot air oven for 48 hours. After drying, the weights were measured and the material was kept in the same oven until the constant dry weight was obtained. The values were expressed in gm plant⁻¹.

Chlorophyll and Carotenoid Content

Collected plant samples in fresh leaf tissues of 500mg were measured and ground in pestle and mortar adding 10ml of 80% Acetone after complete extraction and centrifuge at 800g for 15 minutes, further, the extraction was repeated again and then the supernatant was collected and makeup to a final volume of 20ml of Acetone. The Spectrophotometer is used for absorption of reading @645, 663, 480nm, against 80% acetone blank. Chlorophyll and Carotenoid contents were extracted from the leaves and estimated according to the methods of Arnon's method 1949 and Kirk and Allen 1965 and expressed in mg/gram fresh weight.

STATISTICAL ANALYSIS

The experiment data were analyzed statistically using the SPSS Software {Version 22.0} followed by one-way ANOVA. The obtained data represented in bars are mean values of replicates. The P≤0.05 result was chosen as significance by Duncan's Multiple Range Test [DMRT].

RESULTS AND DISCUSSIONS

Root length

The plants treated with NaCl show a reduction in root length compared to the control. The plants that are foliar applied salicylic acid and humic acid show increased root length compared to the control. While the plants treated with NaCl + Salicylic acid and NaCl + humic acid show a reduction in root length compared to the control and the plants treated with plant growth regulators. (Fig-1) NaCl stress affects the root length of the two different cultivars (cv. *Orhangazi* and cv. *Cumhuriyet*) of *Sesamum indicum* at the concentration of 100 mM Concentration [16]. It's reported that the root length and dry mass were reduced due to salinity in wheat plants [17]. Elevated levels of salinity detrimentally impacted the root development of purslane (*Portulaca oleracea* L.), manifesting in reduced





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metrics such as root area, root volume, main root length, and total root length [18]. And similar decline in growth was seen in *Zea mays* [19].

Stem length

Salt stress reduced the stem length in *Sesamum indicum* L. compared to the control. However, the plants treated with salicylic acid and humic acid show increased stem length as compared to control. The plants treated with NaCl + SA and NaCl + HA showed increased stem length than NaCl treated plants but it was found less than the control.(Fig-2) Elevating the levels of NaCl resulted in a reduction in the lengths of the plants. This investigation was conducted on moth bean (*Vigna aconitifolia* L.) [20], radish plants (*Raphanus sativus* L.) [21], and cowpea (*Vigna unguiculata* L.) [22].Applying small amounts of salicylic acid (SA) to the shoots of seedlings of horticultural plants such as habanero pepper (*Capsicum chinense*) or perennial trees like the Ramon (*Brosimum alicastrum*) significantly boosts their growth, advancement, and yield. [23].

Fresh weight and Dry weight

The height of the plants notably decreased following the introduction of NaCl in comparison to the control group. Through our current research, it was noted that applying NaCl at a concentration of 100mM to *sesamum indicum* L. led to a greater reduction in both fresh and dry biomass of the entire plant when compared to plants in the control group. (Fig- 3,4). The plants treated with salicylic acid and humic acid show increased fresh weight and dry weight compared to the control. However, the plants treated with NaCl + SA and NaCl + HA showed less biomass weight compared to the control. NaCl stress affects the fresh weight and dry weight of plants as found in Rice cultivars [24]. *Brassica napus* [25]. Studies have indicated that the application of humic acid and salicylic acids positively influences the growth, yield, and fruit quality of three cultivars of red sweet pepper (*Capsicum annuum*), leading to enhanced plant growth and increased yield. [26].

Chlorophyll and carotenoid content

The plants treated with NaCl exhibit reduced levels of chlorophyll pigments compared to other groups. Control plants demonstrate higher pigment levels in contrast to plants treated with NaCl along with either SA or HA. Additionally, HA-treated plants show lower pigment content compared to those treated with SA. The concentrations of chlorophyll-a, chlorophyll-b, and total chlorophyll are elevated in plants treated with Salicylic acid. However, the plants treated with NaCl + SA and NaCl + HA chlorophyll pigment content in these plants is low as compared to the control. (Fig-5.6.7.) Salinity reduces the soil water potential which can lead to osmotic stress, and decreased water potential, salinity shows a potent effect on the photosynthetic composition of *sesamum indicum* plants. [27] and in *Plantago coronopus* L. [28] salicylic acid has been found in alleviating the salinity stress in *Zea mays* and in increasing photosynthesis. [29]. Similar results of enhancing the photosynthesis were found in *Solanum lycopersicum* L. [30].

Carotenoid content

The carotenoid content declined in the salt-treated plants. However, the plants treated with salicylic acid and Humic acid have high carotenoid content. However, in the plants treated with NaCl + SA and NaCl + HA, the carotenoid content is less as compared to the control.(Fig-8). The plant growth regulators salicylic acid and humic acid have been found to enhance the pigment composition and carotenoid content in *safflower* [31]. Similar results were found in strawberry [32].

CONCLUSION

Salt stress is recognized as one of the most detrimental environmental challenges impacting the agricultural productivity of numerous crops, leading to adverse effects on plant growth, physiological and biochemical traits, vigor, and photosynthetic pigments. Foliar spray of salicylic acid and humic acid mitigates the salinity effects in *sesamum indicum* L. (TMV-4) variety. Overall plants responded well to the exogenous application of salicylic acid and humic acid. And it can be concluded that the application of salicylic acid and humic acid through foliar spraying





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represents a potential approach to improve salt tolerance in *sesamum indicum* L. Resulting in enhanced growth and development. However, the precise molecular mechanisms underlying their stress protection function require further exploration.

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<p>Stem length</p> <p>cm plant⁻¹</p> <p>Treatments</p> <p>35 days 45 days 55 days</p>	<p>Root length</p> <p>cm plant⁻¹</p> <p>Treatments</p> <p>35 days 45 days 55 days</p>
<p>Fig. 1. Effect of foliar application of SA and HA on Stem length of <i>Sesamum indicum</i> (TMV-4 variety) under 100mM NaCl stress. Values represented in Bars are mean of three replicates (n=3) and (±) standard error.</p>	<p>Fig. 2. Effect of foliar application of SA and HA on Root length of <i>Sesamum indicum</i> (TMV-4 variety) under 100mM NaCl stress. Values represented in Bars are mean of three replicates (n=3) and (±).</p>
<p>Fresh weight</p> <p>gram plant⁻¹</p> <p>treatments</p> <p>35 days 45 days 55 days</p>	<p>Dry weight</p> <p>gram plant⁻¹</p> <p>Treatments</p> <p>35 days 45 days 55 days</p>
<p>Fig. 3. Effect of foliar application of SA and HA on fresh weight of <i>Sesamum indicum</i> (TMV-4 variety) under 100mM NaCl stress. Values represented in Bars are mean of three replicates (n=3) and (±).</p>	<p>Fig. 4. Effect of foliar application of SA and HA on dry weight of <i>Sesamum indicum</i> (TMV-4 variety) under 100mM NaCl stress. Values represented in Bars are mean of three replicates (n=3) and (±).</p>





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<p>Fig. 5. Effect of foliar application of SA and HA on chlorophyll-a of <i>Sesamum indicum</i> (TMV-4 variety) under 100mM NaCl stress. Values represented in Bars are mean of three replicates (n=3) and (±).</p>	<p>Fig. 6. Effect of foliar application of SA and HA on chlorophyll-b of <i>Sesamum indicum</i> (TMV-4 variety) under 100mM NaCl stress. Values represented in Bars are mean of three replicates (n=3) and (±).</p>
<p>Fig. 7. Effect of foliar application of SA and HA on total chlorophyll of <i>Sesamum indicum</i> (TMV-4 variety) under 100mM NaCl stress. Values represented in Bars are mean of three replicates (n=3) and (±).</p>	<p>Fig. 8. Effect of foliar application of SA and HA on carotenoid content of <i>Sesamum indicum</i> (TMV-4 variety) under 100mM NaCl stress. Values represented in Bars are mean of three replicates (n=3) and (±).</p>





Molecular Docking Study to Evaluate Anti-Allergic and Anti-Inflammatory Activity of Siddha Poly Herbal Formulation *Thoothuvalai Nei*

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ABSTRACT

Allergy and inflammation are important pathophysiological features of several disabilities or medical conditions such as common cold, runny nose, nasal congestion and sneezing. It is caused due to release of Histamine in our body. An Indian study reported that prevalence of allergic rhinitis was 11.3% in children aged 6–7 years, and 24.4% in children aged 13–14 years. *Thoothuvalai Nei* is a well-known siddha poly herbal drug which is widely used to treat the *Kabhathodam* and diseases preceeding the *Kabha thodam* like *Sayam* (Tuberculosis), *Elai* (Cold), *Irumal* (Cough), *Kasam*, 96 types of *Seththumanoi*, *Megam*, *Uttinanoi*, *Eraippu* (Asthma), *Vaayvu*, *Kundalavaayvu*. To ensure anti-allergic and anti-inflammatory properties of *Thoothuvalai Nei* through molecular docking against target enzyme Histamine H1 receptor. Docking study were carried out for 20 retrieved phytocomponents (Solasodine, Ascorbic acid, Apigenin, Quercetin, Vasicoline, Piperic acid, Piperine, Gallic acid, Gingerenone-A, Chebuloside, Betulonic acid, Phellandrene, Diosgenin, Palmitic acid, Embelin, Beta-Sitosterol, Germacrene, Nerolidol, kaempferol, Elemicin) against target enzyme Histamine H1 receptor. It is observed that 19 phytochemicals except gallic acid reveals significant interaction with the core active amino acid residues present on the target histamine H1 receptor. This study ensures that Siddha poly herbal formulation *Thoothuvalai Nei* possesses promising anti-allergic and anti-inflammatory activity.

Keywords: Anti-allergic activity, Anti-inflammatory activity, Molecular docking *Thoothuvalai Nei*





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INTRODUCTION

Thoothuvalai Nei is an ancient Siddha medicine indicated for *EraippuNoi* in various Siddha literatures. Most of the ingredients of the *Thoothuvalai Nei* possess expectorant, tonic and stimulant and also have anti-inflammatory, analgesic, antimicrobial and antioxidant activity. Hence here ancient Siddha drug *Thoothuvalai Nei* was subjected to molecular docking analysis against Histamine H1 receptor target to ensure its anti-allergic and anti-inflammatory properties. Molecular docking is a key tool in structural molecular biology and computer-assisted drug design. The goal of ligand-protein docking is to predict the predominant binding mode(s) of a ligand with a protein of known three-dimensional structure[1]. Histamine is a nitrogenous organic compound involved in immune responses such as allergy and it functions by combining with specific cellular histamine receptors such as H1, H2, H3 and H4, which are the members of the family of rhodopsin-like G protein-coupled receptors. The histamine H1 receptor (HRH1) is one of the four histamine receptors, and it plays an important role in different physiological functions such as inflammation, gastric acid secretion, mast cell-mediated chemotaxis and neurotransmitter release when bound to histamine[2]. Binding of phytocomponents with the core amino acid (428 TRP) of the target by forming hydrogen bond will hinder the function of the histamine H1 receptor with PDB – 3RZE. These amino acid residues are functionally responsible for binding of substrate and inhibitors. Thereby phytocomponents which inhibit the target H1 receptor may act as a potential therapeutic agent for management of allergic conditions[3]. Crystalline structure of the target H1 receptor with PDB – 3RZE (Figure.1) was retrieved from protein data bank and protein clean-up process was done and essential missing hydrogen atom were being added. Different orientation of the lead molecules with respect to the target protein was evaluated by Autodock program and the best dock pose was selected based on the interaction study analysis [3].

MATERIALS AND METHODS

Docking calculations were carried out for retrieved phytocomponents against target enzyme H1 receptor. Essential hydrogen atoms, Kollman united atom type charges, and solvation parameters were added with the aid of AutoDock tools[4]. Affinity (grid) maps of $\times \times$ Å grid points and 0.375 Å spacing were generated using the Autogrid program [4]. AutoDock parameter set- and distance-dependent dielectric functions were used in the calculation of the van der Waals and the electrostatic terms, respectively. Docking simulations were performed using the Lamarckian genetic algorithm (LGA) and the Solis & Wets local search method[5]. Initial position, orientation, and torsions of the ligand molecules were set randomly. All rotatable torsions were released during docking. Each docking experiment was derived from 2 different runs that were set to terminate after a maximum of 250000 energy evaluations. The population size was set to 150. During the search, a translational step of 0.2 Å, and quaternion and torsion steps of 5 were applied. The ingredient and retrieved phytocomponents are tabulated in **Table 1**. Ligand Properties of the Compounds Selected for Docking Analysis are given in **Table 2**.

RESULTS

Total of 20 bioactive lead compounds were retrieved from the herbs present in the siddha formulation *Thoothuvalai Nei*. From the reported data of the herbs, It was observed from the outcome of the present investigation that all 19 phytochemicals except gallic acid reveals significant interaction with the core active amino acid residues present on the target histamine H1 receptor. The docking poses of the retrieved phytocomponents with the Histamine H1 receptor (PDB: 3RZE), along with 2D interaction plot analysis and hydrogen bond plotting with core amino acid analysis, are depicted in Figures 2 to 22. The molecular docking studies of compounds against the histamine H1 receptor (PDB: 3RZE) and the interaction of lead compound with amino acid residues against the same receptor are summarized and presented in Tables 4 and 5, respectively.





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DISCUSSIONS

Thoothuvalai Nei, a Siddha poly herbal formulation, is believed to possess potent anti-allergic and anti-inflammatory properties based on empirical evidence. However, the molecular mechanisms underlying these effects remain largely unexplored. In this study, we utilize molecular docking techniques to gain insights into the potential interactions between the bioactive compounds present in *Thoothuvalai Nei* and key proteins involved in allergic and inflammatory pathways. The findings from our molecular docking study provide valuable insights into the potential molecular mechanisms underlying the anti-allergic and anti-inflammatory activities of *Thoothuvalai Nei*. The identified interactions between *Thoothuvalai Nei* compounds and histamine H1 receptor associated with allergic and inflammatory pathways support the traditional claims of its therapeutic efficacy. Further experimental validations, such as in vitro and in vivo studies, are warranted to corroborate the computational findings and establish the translational potential of *Thoothuvalai Nei* in allergic and inflammatory conditions.

CONCLUSION

Based on the results of the computational analysis it was concluded that almost all bio-active compounds present in herbal ingredients belongs to the siddha formulation *Thoothuvalai Nei* possess significant binding against the target histamine H1 receptor by interacting with active amino acid present on the active site thereby it was concluded that these compounds may exerts promising anti-allergic and anti-inflammatory activity.

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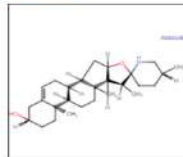
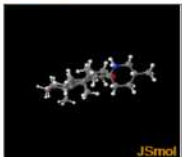




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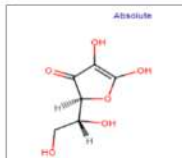

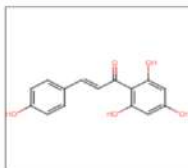
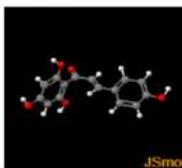
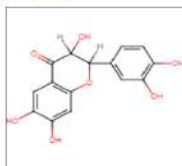
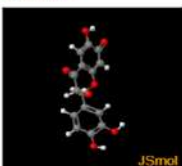
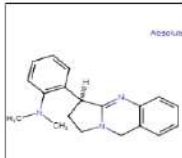

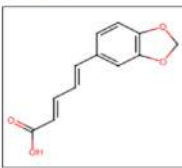
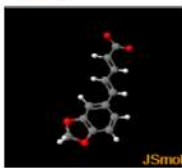
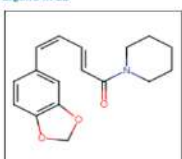
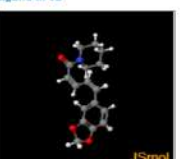
Table 1: List of Phytochemicals Selected for docking

S.No	Herbs	Phytochemicals	2D and 3D Structure of Phytochemicals
1.	<i>Solanumtrilobatum</i>	Solasodine[6]	 





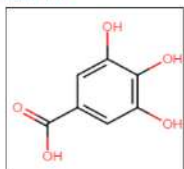
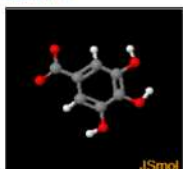
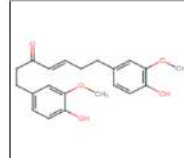
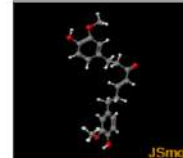
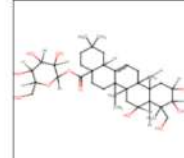

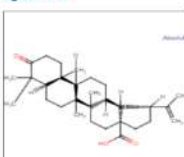

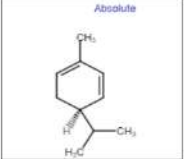
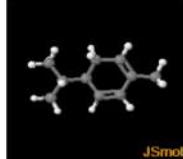
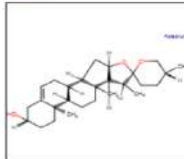
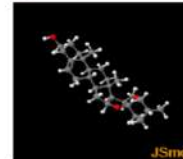
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2.	<i>Solanumanguivi</i>	Ascorbic acid[7]	<p>Ligand in 2D</p>  <p>Ligand in 3D</p> 
3.	<i>Solanumsurattense</i>	Apigenin[8]	<p>Ligand in 2D</p>  <p>Ligand in 3D</p> 
4.	<i>Tragia involucrate</i>	Quercetin[9]	<p>Ligand in 2D</p>  <p>Ligand in 3D</p> 
5.	<i>Justicaadathoda</i>	Vasicoline[10]	<p>Ligand in 2D</p>  <p>Ligand in 3D</p> 
6.	Piper nigrum	Piperic acid[11]	<p>Ligand in 2D</p>  <p>Ligand in 3D</p> 
7.	Piper longum	Piperine[12]	<p>Ligand in 2D</p>  <p>Ligand in 3D</p> 





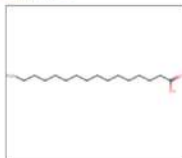

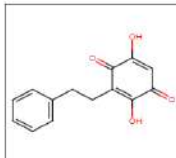
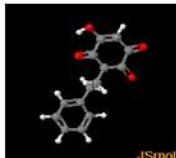
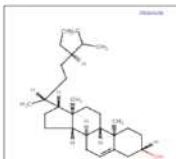
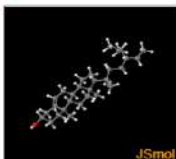
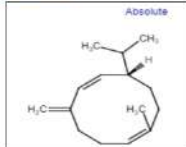

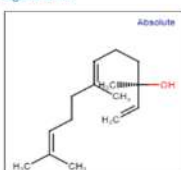
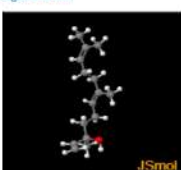
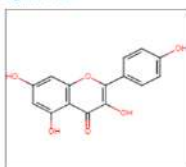
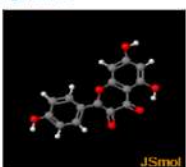
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8.	Terminaliachebula	Gallic acid[13]	 
9.	Tragiacannabina	Unable to Retrieve	
10.	Zingiberofficinale	Gingerenone-A[14]	 
11.	TerminaliaBellarica	Chebuloside [15]	 
12.	Phyllanthusemblica	Betulonic acid[16,17]	 
13.	TaxusBaccata L	Phellandrene[18]	 
14.	Costusspeciosus	Diosgenin[19]	 





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15.	Anacyclus pyrethrum	Palmitic acid[20]	<p>Ligand in 2D</p> 	<p>Ligand in 3D</p>  <p>JSmol</p>
16.	<i>Embeliaribes</i>	Embelin[21]	<p>Ligand in 2D</p> 	<p>Ligand in 3D</p>  <p>JSmol</p>
17.	AlpiniaOfficinarum	Beta-Sitosterol[22]	<p>Ligand in 2D</p> 	<p>Ligand in 3D</p>  <p>JSmol</p>
18.	Alpinia Galangal	Germacrene[23]	<p>Ligand in 2D</p> <p>Absolute</p> 	<p>Ligand in 3D</p>  <p>JSmol</p>
19.	Eletaria cardamom	Nerolidol[24]	<p>Ligand in 2D</p> <p>Absolute</p> 	<p>Ligand in 3D</p>  <p>JSmol</p>
20.	Syzygiumaromaticum	kaempferol [25]	<p>Ligand in 2D</p> 	<p>Ligand in 3D</p>  <p>JSmol</p>





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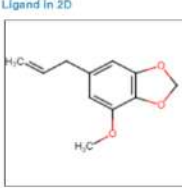

21.	<i>Myristicafragrans</i>	Elemicin[26]	 
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Table 2: Ligand Properties of the Compounds Selected for Docking Analysis

Compound	Molar weight g/mol	Molecular Formula	H Bond Donor	H Bond Acceptor	Rotatable bonds
Solasodine	413.6 g/mol	C₂₇H₄₃NO₂	2	3	0
Ascorbic acid	176.12 g/mol	C₆H₈O₆	4	6	2
Apigenin	622.5 g/mol	C ₂₇ H ₂₆ O ₁₇	9	17	7
Quercetin	302.23 g/mol	C ₁₅ H ₁₀ O ₇	5	7	1
Vasicoline	291.4 g/mol	C₁₉H₂₁N₃	0	2	2
Piperic acid	218.2 g/mol	C₁₂H₁₀O₄	1	4	3
Piperine	285.34 g/mol	C₁₇H₁₉NO₃	0	3	3
Gallic acid	170.12g/mol	C ₇ H ₆ O ₅	4	5	1
Gingerenone-A	356.4 g/mol	C₂₁H₂₄O₅	2	5	9
Chebuloaside	666.8 g/mol	C₃₆H₅₈O₁₁	8	11	5
Betulonic acid	454.7 g/mol	C₃₀H₄₆O₃	1	3	2
Phellandrene	136.23 g/mol	C₁₀H₁₆	0	0	1
Diosgenin	414.6 g/mol	C₂₇H₄₂O₃	1	3	0
Palmitic acid	256.42 g/mol	C ₁₆ H ₃₂ O ₂	1	2	14
Embelin	294.4 g/mol	C₁₇H₂₆O₄	2	4	10
Beta-Sitosterol	414.7g/mol	C ₂₉ H ₅₀ O	1	1	6
Germacrene	204.35 g/mol	C ₁₅ H ₂₄	0	0	1
Nerolidol	222.37 g/mol	C ₁₅ H ₂₆ O	1	1	7
Kaempferol	286.24 g/mol	C₁₅H₁₀O₆	4	6	1
Elemicin	208.25 g/mol	C₁₂H₁₆O₃	0	3	5
Cetirizine	461.808 g/mol	C ₂₁ H ₂₇ Cl ₃ N ₂ O ₃	3	5	8

Table 3: Summary of the molecular docking studies of compounds against histamine H1 receptor (PDB) - 3RZE

Compound	Est. Free Energy of Binding	Est. Inhibition Constant, Ki	Electrostatic Energy	Total Intermolec. Energy	Interact. Surface
Solasodine	-6.92 kcal/mol	8.50 uM	-7.46 kcal/mol	-0.25 kcal/mol	936.402
Ascorbic acid	-6.31 kcal/mol	23.84 uM	-5.33 kcal/mol	-0.28 kcal/mol	468.532
Apigenin	-6.54 kcal/mol	16.09 uM	-7.62 kcal/mol	-0.50 kcal/mol	723.391
Quercetin	-9.23 kcal/mol	170.36nM	-8.17 kcal/mol	-0.49 kcal/mol	692.056





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Vasicoline	-8.39 kcal/mol	711.20 nM	-8.76 kcal/mol	-0.29 kcal/mol	672.097
Piperic acid	-7.60 kcal/mol	2.68 Um	-7.21 kcal/mol	-1.27 kcal/mol	569.362
Piperine	-9.29 kcal/mol	154.70 nM	-9.90 kcal/mol	-0.08 kcal/mol	663.029
Gallic acid	-5.75 kcal/mol	60.52 uM	-3.11 kcal/mol	-2.21 kcal/mol	586.437
Gingerenone-A	-9.20 kcal/mol	180.67 nM	-10.65 kcal/mol	-0.06 kcal/mol	931.043
Chebuloside	-7.87 kcal/mol	1.71 uM	-7.93 kcal/mol	-0.25 kcal/mol	587.645
Betulonic acid	-2.07 kcal/mol	30.33 mM	-2.38 kcal/mol	-0.37 kcal/mol	897.234
Phellandrene	-6.56 kcal/mol	15.55 uM	-6.86 kcal/mol	-0.09 kcal/mol	449.254
Diosgenin	-7.01 kcal/mol	7.33 uM	-7.26 kcal/mol	-0.05 kcal/mol	931.274
Palmitic acid	-7.60 kcal/mol	2.71 uM	-10.15 kcal/mol	-0.92 kcal/mol	751.998
Embelin	-8.80 kcal/mol	354.67 nM	-8.72 kcal/mol	-0.35 kcal/mol	592.191
Beta-Sitosterol	-10.86 kcal/mol	11.01 nM	-12.86 kcal/mol	-0.03 kcal/mol	951.648
Germacrene	-8.19 kcal/mol	988.88 nM	-8.49 kcal/mol	-0.16 kcal/mol	600.235
Nerolidol	-8.02 kcal/mol	1.32 uM	-10.11kcal/mol	-0.05 kcal/mol	621.641
Kaempferol	-7.03 kcal/mol	6.99 uM	-6.67kcal/mol	-0.74 kcal/mol	680.396
Elemicin	-5.79 kcal/mol	56.64 uM	-6.58kcal/mol	-0.06 kcal/mol	562.244
Cetirizine	-11.38 kcal/mol	4.52 nM	-0.83 kcal/mol	-13.28 kcal/mol	895.24

Table 4: Amino acid Residue Interaction of Lead against histamine H1 receptor (PDB) - 3RZE

Compounds	Interactions	Amino acid Residues													
		84	103	107	108	111	112	115	179	198	428	431	432	454	
Solasodine	1	ASN	TRP	ASP	TYR	SER	THR	ILE	LYS	ASN	TRP	TYR	PHE	ILE	
Ascorbic acid	1	TYR	SER	THR	ILE	PHE	PHE	TRP	PHE						
Apigenin	1	ASN	TRP	ASP	TYR	SER	LYS	THR	ALA	TRP	TYR	PHE	PHE	ILE	
Quercetin	1	ASP	TYR	SER	THR	ILE	PHE	PHE	TRP	TYR	PHE	ILE	TYR		
Vasicoline	1	ASP	TYR	SER	THR	THR	ALA	ASN	PHE	PHE	TRP	TYR	PHE	PHE	
Piperic acid	1	TYR	SER	THR	ILE	TRP	PHE	LYS	THR	ASN	PHE	TRP	PHE	PHE	
Piperine	1	TYR	SER	THR	ILE	TRP	PHE	LYS	THR	ALA	ASN	PHE	PHE	TRP	





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Gallic acid	0	84	107	108	179	191	431	435	450	454	458			
		ASN	ASP	TYR	LYS	LYS	TYR	PHE	HIS	ILE	TYR			
Gingerenone-A	1	107	108	111	112	115	178	179	198	199	424	428	431	432
		ASP	TYR	SER	THR	ILE	ASP	LYS	ASN	PHE	PHE	TRP	TYR	PHE
Chebuloaside	1	84	103	107	108	111	112	115	158	178	179	198	428	431
		ASN	TRP	ASP	TYR	SER	THR	ILE	TRP	ASP	LYS	ASN	TRP	TYR
Betulonic acid	1	103	107	108	111	112	158	179	194	198	199	428	431	432
		TRP	ASP	TYR	SER	THR	TRP	LYS	THR	ASN	PHE	TRP	TYR	PHE
Phellandrene	1	108	111	112	115	158	198	199	424	428	432			
		TYR	SER	THR	ILE	TRP	ASN	PHE	PHE	TRP	PHE			
Diosgenin	1	84	103	107	108	111	112	115	179	198	428	431	432	454
		ASN	TRP	ASP	TYR	SER	THR	ILE	LYS	ASN	TRP	TYR	PHE	ILE
Palmitic acid	1	107	108	111	112	179	198	424	428	431	432	454		
		ASP	TYR	SER	THR	LYS	ASN	PHE	TRP	TYR	PHE	ILE		
Embelin	1	107	108	111	112	115	198	199	424	428	431	432	435	
		ASP	TYR	SER	THR	ILE	ASN	PHE	PHE	TRP	TYR	PHE	PHE	
Beta-Sitosterol	1	84	107	108	111	112	115	179	198	199	424	428	431	432
		ASN	ASP	TYR	SER	THR	ILE	LYS	ASN	PHE	PHE	TRP	TYR	PHE
Germacrene	1	108	111	112	158	198	199	424	428	431	432			
		TYR	SER	THR	TRP	ASN	PHE	PHE	TRP	TYR	PHE			
Nerolidol	1	108	111	112	158	194	195	198	424	428	431	432	435	
		TYR	SER	THR	TRP	THR	ALA	ASN	PHE	TRP	TYR	PHE	PHE	
Kaempferol	1	107	108	111	112	115	198	428	431	432	435	458		
		ASP	TYR	SER	THR	ILE	ASN	TRP	TYR	PHE	PHE	TYR		
Elemicin	1	111	115	158	194	198	424	428	432					
		SER	ILE	TRP	THR	ASN	PHE	TRP	PHE					
Cetirizine	1	84	107	108	111	112	178	179	191	428	431	432	435	
		ASN	ASP	TYR	SER	THR	ASP	LYS	LYS	PHE	TYR	PHE	PHE	





<p>Figure.1:3D- Structure of the histamine H1 receptor (PDB) - 3RZE</p>	<p>Figure.2: Solasodine with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>
<p>Figure.3 : Ascorbic acid with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>	<p>Figure.4 :Apigenin with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>
<p>Figure.5 :Quercetin with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>	<p>Figure.6 :Vasicoline with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>





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<p>Figure.7 : Piperinic acid with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>	<p>Figure.8 :Piperine with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>
<p>Figure.9 : Gallic acid with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>	<p>Figure.10 :Gingerenone-A with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>
<p>Figure.11 :Chebuloside with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>	<p>Figure.12: Betulonic acid with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>





<p>Figure.13: Phellandrene with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>	<p>Figure.14: Diosgenin with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>
<p>Figure.15: Diosgenin with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>	<p>Figure.16: Embelin with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>
<p>Figure.17: Beta-Sitosterol with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>	<p>Figure.18: Germacrene with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>





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<p>Figure.19: Nerolidol with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>	<p>Figure.20: Kaempferol with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>
<p>Figure.21: Elemicin with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>	<p>Figure.22: Cetirizine with Histamine H1 receptor (PDB) - 3RZE, 2D Interaction Plot Analysis, Hydrogen bond plotting with core amino acid Analysis</p>





Taxonomy, Distribution and Identification of Two Plant Parasitic Nematode Species Infesting Crops in Jammu and Kashmir, India

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ABSTRACT

The present study reports the taxonomy, distribution, and identification of two prominent plant-parasitic nematode species from litchi (*Litchi chinensis*) orchards in the region of Jammu and Kashmir, India. *Aporcelaimellus obtuse caudatus* has been documented specifically in litchi orchards, where as *Orientyluscitri* has been observed in mixed cropping apple orchards alongside cucurbits. Detailed morphological were conducted to characterize these nematode species, facilitating accurate identification. Understanding the taxonomy and distribution of these nematodes is essential for devising effective management strategies to mitigate their impact on litchi and other crops in the region.

Keywords: Plant parasitic nematodes, Nematodes, Crops, Damage, Litchi, Apple, Jammu

INTRODUCTION

Plant-parasitic nematodes, microscopic worms, represent a formidable menace to global agriculture by inflicting extensive harm on crops [1-3]. These nematodes, originating from various genera, infiltrate the roots of numerous crops, resulting in diminished nutrient absorption, hindered growth, and eventual yield reduction [4]. Recent research endeavors have presented the intricate interplay between plant hosts and nematodes, elucidating the molecular mechanisms underlying nematode parasitism [5]. By investigating into the molecular intricacies of nematode-plant interactions, researchers have identified key pathways and molecules involved in nematode



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invasion, feeding, and manipulation of host physiology [6]. This deeper understanding opens avenues for the development of targeted strategies to disrupt these interactions and enhance plant resistance to nematode infestation [7]. Moreover, advancements in nematode management strategies extend beyond conventional chemical control methods. Researchers are exploring alternative approaches such as the use of biocontrol agents, soil amendments, and cultural practices to mitigate nematode damage sustainably [8]. These environmentally friendly methods offer promise for reducing reliance on chemical pesticides and promoting the long-term health and productivity of agricultural ecosystems. As researchers continue to unravel the complexities of nematode-plant interactions and innovate in nematode management, the agricultural community moves closer to achieving sustainable and resilient crop production systems capable of withstanding the threats posed by plant-parasitic nematodes [9].

The genus *Aporcelaimellus* Heyns, 1965, classified within the family Aporcelaimidae (Heyns, 1965), predominantly preys upon Oligochaeta worms and nematodes [9]. These nematodes typically possess a robust medium-sized body structure characterized by an offset labial region, a short odontostyle featuring a large aperture, a short rounded tail, and two distinct cuticle layers with differing refractive properties [10]. Male specimens are seldom encountered within this genus. *Aporcelaimellus* is widely distributed and ranks among the most prevalent soil nematodes. Notably, the species *A. obtusicaudatus* (Bastian, 1865) Altherr, 1968 stands out as one of the most ubiquitous terrestrial nematodes, with its range extending across the globe [11]. Researchers have examined and distinguished the genera *Orientylus* and *Calvatylus*. They transferred four species from *Rotylenchus* to *Orientylus*, renaming them as *O. helicus* n.comb., *O. citri* n.comb., *O. secundus* n.comb., and *O. siddiqii* n.comb. Additionally, they identified a new species, *O. geraerti* n.sp., discovered in soil surrounding grass roots in Dalhousie, District Chamba, H.P., India[12].

The present study represents a significant contribution to the understanding of plant-parasitic nematodes in the region by providing the evidence of two nematode species from Jammu and Kashmir, India. This report adds a crucial part to the nematode distribution and diversity in the northwestern Himalayas, shedding light on the geographical range of this particular species. Understanding the dynamics of nematode populations in this region is essential for farmers, agronomists, and researchers to implement effective and sustainable measures to mitigate potential crop losses. This finding emphasizes the importance of continuous monitoring and research efforts to stay ahead of emerging plant health threats and underscores the need for global collaboration to address the challenges posed by plant-parasitic nematodes.

MATERIALS AND METHODS

As a part of the nematode diversity assessment in Jammu and Kashmir, soil samples were collected from Tehsil Akhnoor in District Jammu, located at coordinates 32°.87' N 74°.73' E, at an altitude of 301 m (988 ft.) and District Doda, GandohBalessa, 33.0322° N, 75.9100° E, 662m (Fig. 1). The collection was made in September 2023 from an agricultural land with grapevines, at depths ranging from 0 to 15 cm and 10 to 20 cm. In order to inhibit evaporation, the samples were meticulously preserved in polythene bags that were tightly fastened with rubber bands. The Baerman funnel technique and decanting method was used for nematode isolation during the processing of soil samples. Using the Baerman funnel method, the turbid solution was delicately agitated manually to disintegrate clumps. The solution was further filtered using a coarse sieve to remove any unwanted particles, and then passed through a 300-micron mesh sieve to specifically catch root nematodes by Cobb's sieving and decanting method and Baermann funnel technique [13, 14]. The decantation technique involves the amalgamation of soil and water, followed by the process of sedimentation, and finally, the separation of the water by pouring it out. The mud suspension was deposited onto a petri dish containing a small quantity of water, thereby exposing nematodes suspended or attached to the surface of the dish. Individual live nematodes were selected using a size 0 brush. The nematodes were exterminated by immersing them in test tubes containing a solution of 70 percent alcohol. They were then kept undisturbed for a duration of 24 hours prior to further handling. Lactophenol was used for the purpose of conducting morphological and anatomical analysis, namely during the process of cleaning and mounting. Accurate categorization of nematodes was achieved by the use of morphological and image-based analysis. For the





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identification of nematodes, temporary slides were made and studied under Olympus BX51 compound microscope and identification was confirmed with the help of available literature [12, 15, 16, 17, 18, 19].

RESULTS

Species account

Phylum: NEMATODA

Order: DORYLAIMIDA

Family: APORCELAIMIDAE Heyns, 1965

Subfamily: APORCELAIMINAE Heyns, 1965

Genus: *Aporcelaimellus* Heyns, 1965

Species: *Aporcelaimellus obtusicaudatus* (Bastian, 1865) Altherr, 1968

Basionym: *Dorylaimus obtusicaudatus* Bastian, 1865

Synonyms:

- =*Aporcelaimellus barelicus* Jain & Saxena, 1993
- = *Aporcelaimellus futaii* Khan & Araki, 2002
- =*Aporcelaimellus kazirangus* Khan, Ahmad & Jairajpuri, 1995
- =*Aporcelaimellus microhystera* Altherr, 1972
- = *Aporcelaimellus micropunctatus* Botha & Heyns, 1990
- =*Aporcelaimellus obscuroides* Altherr, 1968
- =*Aporcelaimellus obscurus* (Thorne & Swanger, 1936) Heyns, 1965
- =*Aporcelaimellus porcus* Thorne, 1974
- =*Aporcelaimellus quietus* (Kirjanova, 1951) Baqri & Khera, 1975
- =*Aporcelaimellus vanderlaani* (Meyl, 1957) Heyns, 1965
- =*Aporcelaimellus williamsi* Heyns, 1965
- =*Aporcelaimus obscurus* (Thorne & Swanger, 1936) Goodey, 1963
- =*Aporcelaimus vanderlaani* Meyl, 1957
- ≡*Dorylaimus obscurus* Thorne & Swanger, 1936
- ≡*Dorylaimus obtusicaudatus* Bastian, 1865
- =*Dorylaimus ornatus* Fuchs, 1930
- =*Dorylaimus perfectus* Cobb, 1893
- =*Dorylaimus quietus* Kirjanova, 1951
- =*Eudorylaimus obscurus* (Thorne & Swanger, 1936) Andrassy, 1959
- =*Eudorylaimus obtusicaudatus* (Bastian, 1865) Andrassy, 1959
- =*Eudorylaimus quietus* (Kirjanova, 1951) Andrassy, 1959

Species examined

1 ♀, INDIA, Jammu and Kashmir, District Jammu, Tehsil Akhnour, 32° .87' N 74° .73' E, 301m, 19.09.2023, Jatinder Singh, Voucher specimen (DOZ-J&K-25).

Distribution and Host Range

Aporcelaimellus obtusicaudatus are soil-dwelling nematodes with a predilection for consuming bacteria and algae as part of their free-living lifestyle [20].

Species Description

The female *Aporcelaimellus obtusicaudatus* (Bastian, 1865) Altherr, 1968 exhibited a slender and elongated body morphology, which was typical of the genus with total body size (2.5 mm) (Fig. 2). The cuticle was finely annulated, appearing smooth under light microscopy. The lip region was rounded and slightly offset from the rest of the body. The stylet was robust and well-developed, bearing three prominent knobs at its base. The esophageal glands were



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prominent, extending posteriorly towards the intestine. The vulva was located approximately at the mid-body region and was characterized by a slightly raised vulval lip. The tail was bluntly rounded, with a distinct hyaline terminus. Morphometric measurements of body length, stylet length, esophageal length, and tail length were consistent with the species description. Overall, these morphological features distinguished the female *A. obtusicaudatus* from other members of the genus, facilitating its taxonomic identification.

Species account

Phylum: NEMATODA

Order: DORYLAIMIDA

Family: HOPLOLAIMIDAE Filipjev, 1934

Subfamily: HOPLOLAIMINAE Filipjev, 1934

Genus: *Rotylenchus* Filipjev, 1936

Species: *Orientylus citri* (Rashid & Khan, 1973) Jairajpuri & Siddiqi, 1977

Basionym: *Rotylenchus citri* Rashid & Khan, 1973

Species examined

1 ♂, INDIA, Jammu and Kashmir, District Doda, Gandoh Balessa, 33.0322° N, 75.9100° E, 662m, 24.09.2023, Jatinder Singh, Voucher specimen (DOZ-J&K-27).

Distribution and Host Range

The host of *Orientylus citri*, formerly classified as a species of *Rotylenchus*, primarily includes citrus plants. This nematode species is known to infest various citrus species, such as oranges, lemons, grapefruits, and mandarins, among others [21]. It can cause damage to citrus trees by feeding on the roots, leading to stunted growth, reduced yield, and susceptibility to other diseases. Additionally, in some cases, *Orientylus citri* has been reported in association with other crops or plants in citrus-growing regions, potentially indicating a broader host range under specific environmental conditions [22].

Species Description

The male specimen typically exhibited a slender and elongated body shape, with a distinctively shaped lip region and body size (0.99mm) (Fig. 3). Its stylet is well-developed and often bears prominent knobs at its base. The esophageal glands were observable, extending posteriorly toward the intestine. Males of *Orientylus citri* are relatively rare compared to females. Additional features included the presence of spicules and a gubernaculum, which are structures associated with reproduction in male nematodes. Detailed morphological and morphometric measurements are often employed to accurately characterize and differentiate male *Orientylus citri* specimens from other closely related species within the genus.

DISCUSSION

In our comprehensive examination, *Aporcelaimellus obtusicaudatus* emerges as a pivotal species within soil nematode communities, showcasing not only its extensive geographical distribution but also its remarkable adaptability to various ecological niches. By elucidating its feeding preferences, which predominantly target bacteria and algae, alongside detailing its unique morphological features and habitat preferences, we contribute to a deeper understanding of its ecological role. Moreover, our findings underscore the need for further investigations into its interactions with other soil organisms and its potential implications for soil health and nutrient cycling dynamics. Meanwhile, our exploration of *Orientylus citri*, previously classified under *Rotylenchus*, untangles insights into its host specificity, particularly its affinity for citrus plants, thereby highlighting its significant implications for citrus cultivation. The detailed characterization of its morphological traits aids not only in its accurate identification but also in the development of targeted management strategies to mitigate its detrimental impact on citrus orchards. As we investigate deeper into the ecological nuances of these nematode species, there remains a pressing need for





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ongoing research efforts aimed at unraveling their broader ecological roles and devising sustainable management practices for agricultural systems worldwide.

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Fig. 1. Map of the study areas showing red spots where species were collected

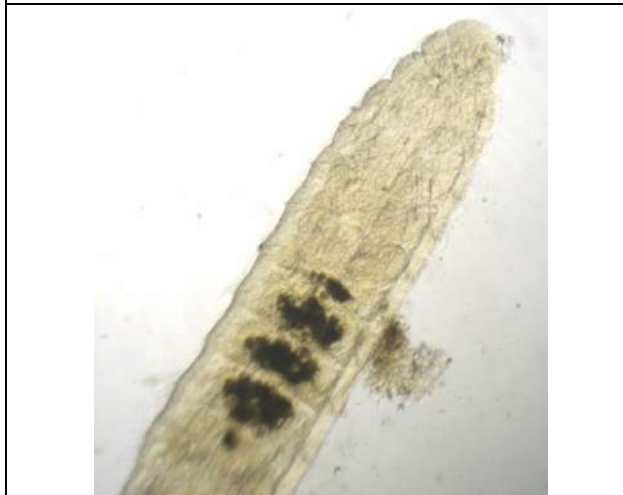


Fig. 2. ♀ *Aporcelaimellus obtusicaudatus*



Fig. 3. ♂ *Orientylus citri*





Antimicrobial and Cleansing Properties of Protease Enzyme Isolated from Coconut shells

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ABSTRACT

Cocos nucifera (CN), commonly known as Coconut tree, has many applications. Generally, coconut shells are considered as waste product. Coconut shells can be used as a source of protease enzyme. Protease enzyme from the coconut shells have many applications. Protease enzyme was extracted from the coconut shell and it was characterized. In this study our aim was to assess the antimicrobial and Cleansing activity (Bloodstain removal), of the coconut shell protease enzyme. The agar disc diffusion method was used for antibacterial and antifungal screening. Protease enzyme from the coconut shell shows excellent inhibitory activity against both gram-positive and gram-negative bacterial strains. The Blood stain removal was done by wash test method. Stains were removed when they were treated with a combination of Coconut shell protease and commercial detergent. This would be used as an alternative in detergent making industries and it is eco - friendly.

Keywords: Coconut shell Protease, antibacterial, antifungal, Blood Stain Removal.





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INTRODUCTION

The genus *Cocos* (coconut) is a member of the *Aracaceae* family. The nutritional and therapeutic characteristics of coconut make it a popular tropical fruit in many nations. The majority of the time, coconut meats are utilized as a staple meal, while other coconut plant parts can be used to make wood and crafts. Throughout history, coconut has also been known as a source of essential oils with biological activity. Coconut shell is a component of coconut that is rarely used in high-value goods. Traditionally, coconut shell is burnt and utilized in cooking. This approach may cause air pollution. At the moment, agricultural waste is receiving greater attention than in the past. Since it is less expensive also more effective for the creation of natural goods, and the best waste disposal option. Particularly, in underdeveloped nations, infectious infections are a significant cause of death and disability among the general population.[1] As microorganisms are increasingly becoming resistant to traditional antimicrobials, in recent years pharmaceutical companies have been driven to create novel antimicrobial medications. There are common reports on bacterial isolates that are known to be sensitive to commonly used drugs but which have become multi-resistant to other medications that are available on the market.[2] This suggests that bacterial species possess the genetic ability to acquire therapeutic properties. Several pathogenic and spoilage bacteria and fungi are becoming more and more resistant to drugs. The focus of scientific research in this area is shifting toward natural ingredients.[3] The growth of pathogenic and spoilage microbes can be slowed by using plant protease enzymes with antimicrobial characteristics from a variety of sources, including fruits, leaves, peels, and herbs. These days, plant Protease is used as an inexpensive, effective, and completely acceptable organic food additive in all industries [4]. It is becoming more popular to use biological resources and by-products to extract bioactive compounds with antimicrobial effects. [5] Existing research has demonstrated that the partly purified proteolytic extract of the pineapple, fig, papaya, etc., shows antibacterial activity against gram-positive and gram-negative bacteria.

Proteases are most often used in laundry detergents, where they help in the removal of stains caused by protein.[16] Protein stains are attacked by protease enzymes, which break down protein molecules into shorter chains of amino acids that may be readily removed from the cloth after washing.[6] Proteases are also expected to play a significant role in the development of environmentally friendly technologies as well as in many bioremediation procedures. Proteases can break down proteins into peptides and amino acids. They are distinguished by the temperature and pH at which they function best in removing the stains. Their capacity to hydrolyse specific proteins has drawn considerable interest as a potential chemical alternative. An enzyme should be stable and active in the presence of common detergent additives, such as surfactants, bleach activators, builders, fillers, bleaching agents, fabric softeners, and many other formulation additives.[7] Proteases may also be employed in the textile industry to remove the stiff and unappealing gum coating of sericin from the raw silk fiber in order to increase the luster and softness. Wool and silk fibers can undergo protease treatments to change their surface, creating novel and distinctive finishes.[8] Protease addition to detergents significantly improves (35–40%) cleaning performance (especially in eliminating stains containing proteins, such as blood) and enhances the consumption of surface-active compounds, Surface active compounds are molecules that can adsorb to solid surfaces or fluid interfaces, allowing them to function as multifunctional ingredients, hence enhancing the ecological situation.[9] The objective of this study was to investigate the impact of the purified proteolytic extract (Protease enzyme) from the Coconut shell for the antimicrobial and stain removal activity.

MATERIALS AND METHODS

COCONUT SHELL PROTEASE ENZYME EXTRACTION

10 grams of coconut shell powder was weighed and soaked in 100 ml of Hydroalcohol solvent, heated in a water bath at 100°C for 15 minutes, and kept for incubation for over 48 hrs. After incubation the extract was filtered and the collected extract was taken for the purification and characterization process. After purification, the purified protease enzymes were checked for antimicrobial and Cleansing properties. [10]



**Hema and Poongothai****DETERMINATION OF ANTIMICROBIAL ACTIVITY****ANTIBACTERIAL ACTIVITY**

The antibacterial activity of coconut shell protease enzyme was tested against both Gram-positive and gram-negative bacteria (*Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhi*, and *Bacillus sp.*), and the zone of inhibition were recorded (figure: 1 and table:1). Ampicillin (1mg/ml) and Penicillin (1mg/ml) was used as positive control; negative control was double distilled water. In *Pseudomonas aeruginosa* and *Salmonella typhi* inoculated plates, the maximum zone of inhibition was observed. Coconut shell liquid smoke inhibited only gram-positive bacteria (Kailaku et al., 2017) and in the case of coconut husk extract maximum inhibition was found only in gram-negative bacteria. Coconut shell protease had excellent antibacterial activity against *Staphylococcus aureus* (13mm), *Escherichia coli* (15mm), *Pseudomonas aeruginosa* (20mm), *Salmonella typhi* (19mm), and *Bacillus sp.* (16mm). Of different bacteria tested, Coconut shell protease showed maximum inhibition against *Pseudomonas aeruginosa* (20mm), compared to standard antibiotic penicillin (14mm). The zone of inhibition in *Salmonella typhi* was measured as 19 mm which was similar to that of the standard antibiotic ampicillin (20mm) Temikotan et al., 2021). When compared to other studies that show antimicrobial properties for coconut husk extract and coconut shell liquid smoke, the current study on antimicrobial property of coconut shell protease demonstrated that it inhibited both gram-positive and gram-negative bacteria. Hence Coconut shell protease can be exploited for its effective antimicrobial nature.

ANTIFUNGAL ACTIVITY

The antifungal activity of coconut shell protease was tested against *Aspergillus niger* and *Candida albicans* and the results were recorded. The results were shown in Figure: 2 and table: 2. Coconut shell proteases possess antifungal activity for the fungi like *Aspergillus niger* and *Candida albicans*. In *Aspergillus niger*, Amphotericin B was used as positive control and the zone of inhibition was measured as 14 mm and the zone of inhibition of the enzyme was measured as 10mm. In the case of *Candida albicans* the maximum zone of inhibition was noted as 30mm, which is higher than the standard antibiotic Fluconazole (14mm). When compared to *Aspergillus niger*, *Candida albicans* shows the maximum zone of inhibition (30mm). Earlier studies by Jayasree et al., 2019 reported that coconut shell oil shows the maximum zone of inhibition (30mm) against *Candida albicans* which is found equal to the zone of inhibition (30mm) exhibited by coconut shell protease. Ethanol extract from coconut shells shows maximum inhibition for *C. albicans* because of the presence of phenols and other metabolites in it. Coconut shell liquid smoke does not inhibit the growth of *Candida sp.*, (Kailaku et al., 2017). Current research and earlier literature conclude that coconut shell protease plays a prominent role in inhibiting the growth of fungi and ensures that it can act as a best antibiotic for fungal infections.

Blood stain removal

Coconut shell powder proteases were also used to remove the blood stains on clothes. Blood stain removal was studied by washing test. For this study, five white cotton cloth pieces were taken (5cm X 5cm) and stained with blood, then it was dried at 95 - 100°C in the oven for 5 minutes. The stained clothes were used for stain removal studies. Five different sets of treatments were given as follows. Set 1: Water (100 ml) + empty cloth (control), Set 2: Water (100 ml) + blood stained cloth (control), Set 3: Water (100 ml) + blood stained cloth + 2 ml of partially purified enzyme (1.5 U/ml). Set 4: Water (100 ml) + blood stained cloth + 1 ml of commercial detergent (5 mg/ml) + 1ml of partially purified enzyme (1.5 U/ml). Set 5: Water (100 ml) + blood stained cloth + 2 ml of commercial detergent (5 mg/ml). Set 6: Water (100 ml) + blood stained cloth + 1 ml of commercial detergent (5 mg/ml) + 2 ml of partially purified enzyme (1.5U/ml). The stained cloths were incubated for 10 minutes at 55°C. In each set of treatments, three pieces of cotton cloth were maintained. After incubation, the cotton pieces from each set were removed, cleaned with distilled water, dried, and visually examined. Blood-stained cotton pieces that had been treated with water were used as a control.





RESULTS AND DISCUSSION

COCONUT SHELL PROTEASE ENZYME EXTRACTION

Protease enzyme was isolated from Coconut shell powder at 100°C. The extracted protease enzyme was checked by qualitative and quantitative analysis. Coconut shell proteases have 1.1 mg/ml of protein and 1.5U/ml of protease in them. Characterization studies were carried out. In this study, the antimicrobial and Cleansing activity of Coconut shell protease were checked.

DETERMINATION OF ANTIMICROBIAL ACTIVITY

ANTIBACTERIAL ACTIVITY

The antibacterial activity of coconut shell protease enzyme was tested against both Gram-positive and gram-negative bacteria (*Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhi*, and *Bacillus sp.*), and the zone of inhibition were recorded (figure: 1 and table: 1) In this positive control used was Ampicillin (1mg/ml) and Penicillin(1mg/ml); negative control was double distilled water. In *Pseudomonas aeruginosa* and *Salmonella typhi* inoculated plates, the maximum zone of inhibition was observed. Other bacteria were also inhibited by the coconut shell protease enzyme. When compared to other studies that show antimicrobial properties for coconut husk extract, coconut shell extract and coconut shell liquid smoke this coconut shell protease inhibits both gram-positive and gram-negative bacteria, but in that case, the coconut shell liquid smoke inhibits only the gram-positive bacteria (Kailakuet *al.*, 2017) and in the case of coconut husk extract maximum inhibition was found only in gram-negative bacteria (Temikotan *et al.*, 2021). Hence Coconut shell protease enzyme inhibits both gram-positive and gram-negative bacteria.

ANTIFUNGAL ACTIVITY

The antifungal activity of coconut shell protease enzyme was tested against *Aspergillus niger* and *Candida albicans* and the results were recorded. The results were shown in Figure: 2 and table: 2. When compared to *Aspergillus niger*, *Candida albicans* shows the maximum zone of inhibition (30mm). In earlier studies, Jayasreeet *al.*, 2019 reported that coconut shell oil shows the maximum zone of inhibition against *Candida albicans* which is equal to the zone of inhibition of coconut shell protease enzymes. Ethanol extract from coconut shells shows maximum inhibition for *C. albicans* because of the presence of phenols and other metabolites in it. Coconut shell liquid smoke does not inhibit the growth of *Candida sp.*, Kailakuet *al.*, 2017. Current research and earlier literature conclude that coconut shell protease plays a prominent role in inhibiting the growth of fungi and it would act as a best antibiotic for fungal infections.

Blood stain removal

In this present study, partially purified protease from coconut shell powder has been used as the cleansing supplement in blood stain removal along with the commercial detergent (Surf excel). Results were shown in the figure 3(a), 3(b) and 3(c). Figure 3(a) explains the 6 different sets of blood-stained clothes for the stain removal treatment and figure 3(b) shows the dried blood-stained clothes and in figure 3(c) shows the stain-removed clothes after the treatment with Coconut shell protease enzyme and with commercial detergent. Totally 6 different treatments were used for this assay, in that Set1 plain cloth was kept as negative control and it was treated with 100 ml of distilled water. In set 2 the blood-stained cloth was used as positive control and it is treated with 100 ml of distilled water. In set 3 the blood-stained cloth was treated with 100 ml of distilled water along with 1 ml of commercial detergent (5 mg/ml) and 2 ml of partially purified enzyme (3 U). In set 4 the blood-stained cloth was treated with 100 ml of distilled water along with 1 ml of commercial detergent (5 mg/ml) and with 1 ml of partially purified enzyme (1.5U) and in set 5 the blood-stained cloth was treated with 100 ml of distilled water and with 2ml of partially purified enzyme (3U). In set 6 the blood-stained clothe was treated with 100 ml of distilled water and with 2 ml of commercial detergent (5mg/ml) of all the treatments. Treatment 3 shows a much better result in removing the stain than the other set of treatments. The study concluded that the combination of the Coconut shell Protease and the commercial detergent shows excellent activity in stain removal. The blood stain was partially removed when they





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were treated with Coconut shell protease alone and stains were partially removed when they were treated with commercial detergent alone. Shanmugavel *et al.*, 2016 reported that protease enzyme from *Aspergillus tamari* was used for treating the blood-stained clothes with a combination of commercial detergent (7mg/ml) for 10 mins and the blood stains were removed. Similarly in current study, the blood stains were removed when they were treated with 5mg/ml of commercial detergent along with 2 ml of the coconut shell protease enzyme for 10 mins. It shows that the enzyme from coconut shell protease gave a better result than the *Aspergillus tamari* protease enzyme. Suryawanshi *et al.*, 2017, reported that protease obtained from *Aspergillus niger* and *Trichoderma longibrachiatum* have cleansing properties. Blood-stained clothes were treated with 1% commercial detergent and 1 ml of enzyme of *Aspergillus niger* for 1 hour and *Trichoderma longibrachiatum* shows moderate results in blood stain removal with the combination of 1% commercial detergent and 1 ml of enzyme of *Trichoderma longibrachiatum* for 1 hour. These results also show that coconut shell protease has better cleansing properties than other protease enzymes.

CONCLUSION

From this study, we could conclude that the Coconut shell protease enzyme shows both antimicrobial activity and cleansing activity. Protease extracted from coconut shell at 100°C does not affect the antimicrobial and cleansing activity. This will be useful for the production of antibiotics against disease-causing organisms and also it will protect the environment from getting polluted. This Coconut shell protease would be used as an alternative to hazardous chemicals in the detergent industry in making detergent for laundry purposes.

CONFLICT OF INTEREST

Conflict of interest declared none.

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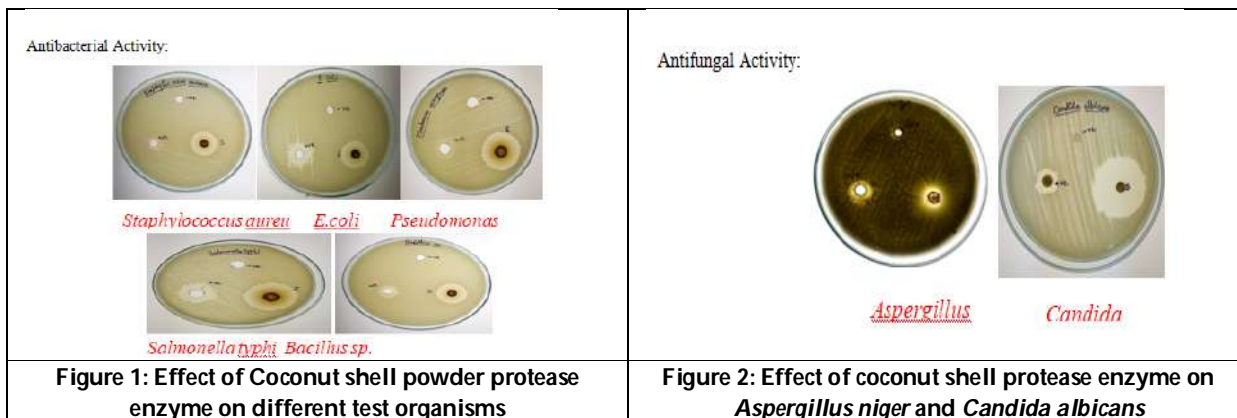
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Table 1: Antibacterial activity of coconut shell protease enzyme on different test organisms

Test Organism	Zone of Inhibition (mm)		
	Positive Control	Negative Control	Coconut shell protease enzyme
<i>Staphylococcus aureus</i>	8	0	13
<i>Escherichia coli</i>	17	0	15
<i>Pseudomonas aeruginosa</i>	14	0	20
<i>Salmonella typhi</i>	20	0	19
<i>Bacillus sp.</i>	13	0	16

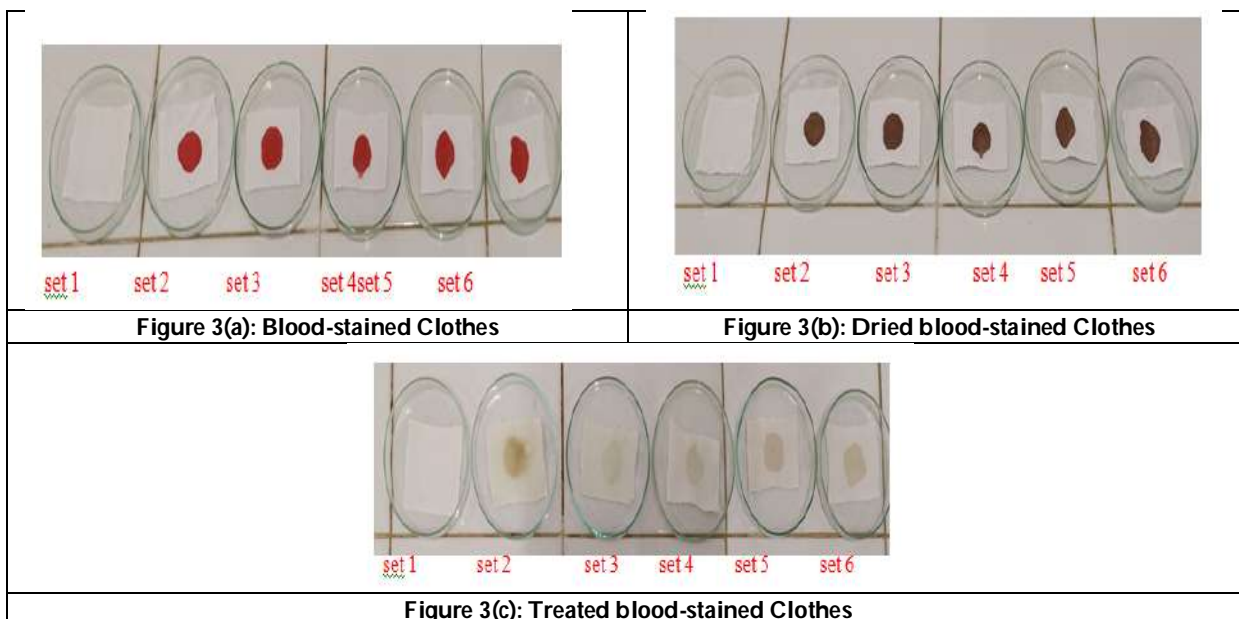
Table 2: Antifungal activity of coconut shell protease enzyme o *Aspergillus niger* and *Candidaalbicans*

Test Organism	Zone of Inhibition (mm)		
	Positive Control	Negative Control	Coconut shell protease enzyme
<i>Candidaalbicans</i>	14	0	30
<i>Aspergillus niger</i>	14	0	10





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Note

- Set 1- water (100 ml) + empty cloth (Negative control)
- Set 2- water (100 ml) + blood stained cloth (Positive control)
- Set 3 - distilled water (100 ml) + blood stained cloth + 1 ml of commercial detergent (5 mg/ml) + 2 ml of partially purified enzyme
- Set 4 - water (100 ml) + blood stained cloth + 1 ml of commercial detergent (5 mg/ml) + 1ml of partially purified enzyme
- Set 5 - water (100 ml) + blood stained cloth + 2 ml of partially purified enzyme.
- Set 6 - distilled water (100 ml) + blood stained cloth + 2 ml of commercial detergent (5 mg/ml).





Antimicrobial Activities of Green and Black Tea (*Camellia sinensis*) extracts against Pathogens

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ABSTRACT

The present study evaluated the antimicrobial (AM) activity of aqueous extracts derived from green and black tea (*Camellia sinensis*). Given the growing interest in natural antimicrobial agents, understanding the effectiveness of these commonly consumed teas against various pathogens is crucial for potential therapeutic applications. Multiple samples of tea were collected, and their aqueous extracts were tested for their AM activity against *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Salmonella typhi*. The green and black tea extracts demonstrated significant AM activity ($P < 0.001$) against all selected pathogens. However, green tea exhibited higher antimicrobial efficacy than black tea, particularly in inhibiting *P. aeruginosa*. Packaged tea varieties showed superior antimicrobial activity compared to open forms. Additionally, the minimum inhibitory concentration (MIC) value of all four aqueous extracts (open and packaged green and black teas) displayed potent growth inhibition against the test pathogens. Packaged green and black teas showed MIC values ranging from 400-800 $\mu\text{g/mL}$, while open tea forms showed MIC values ranging from 400-1400 $\mu\text{g/mL}$ against the pathogens. Consequently, it can be concluded that aqueous extracts from *C. sinensis* leaves have the potential to be used as natural AM agents against *E. coli*, *S. aureus*, *P. aeruginosa*, and *S. typhi* pathogens.



**Barkha Bhatnagar et al.,****Keywords:** *Escherichia*, Minimum inhibitory concentration, *Pseudomonas*, *Salmonella*, *Staphylococcus*

INTRODUCTION

Tea is an aromatic beverage crafted from the leaves and buds of the *Camellia sinensis* plant, an evergreen shrub native to Asia[1][2][3]. It is the second most widely consumed beverage globally, surpassed only by water and outstripping the consumption of coffee, beer, wine, and carbonated soft drinks[4]. Teas are categorized into three main types based on their manufacturing process. The first is non-fermented green tea, which undergoes drying and steaming to prevent oxidation; the second is semi-fermented oolong tea, subjected to partial fermentation before drying; and the third is fermented black and red teas, which undergoes post-harvest fermentation, catalyzed by polyphenol oxidase for black tea and by microorganisms for red tea[5][6]. Among the components found in green tea leaves, polyphenols stand out, making green tea a significant dietary source of flavonoids. Conversely, black tea predominantly contains polymerized catechins like theaflavins and thearubigins. These catechins and polyphenols have demonstrated antimicrobial properties, potentially inhibiting various pathogens[7][8][9][10]. The daily moderate consumption of green tea has been observed to eliminate pathogens such as *Bacillus cereus*, *Clostridium perfringens*, *Pleisomonas shigelloides*, *Staphylococcus aureus*, and *Vibrio parahemolyticus*[7]. The antimicrobial effects of catechins involve direct actions such as damaging bacterial cell membranes, inhibiting fatty acid synthesis, and suppressing enzyme activity. Additionally, they contribute to overall antimicrobial efficacy by inhibiting inflammation, induced by oxidative stress, increasing nitric oxide synthesis, inhibiting angiotensin II and interleukin 6 (IL-6)-induced C-reactive protein expression, suppressing IL-6 and receptor activator of nuclear factor kappa beta (RANKL) production in infected osteoblast-like cells, inhibiting IL-8 production, and suppressing hyaluronidase activity activated by chronic inflammation via IL-12 inhibition [11][12][13][14][15]. Despite significant efforts to explore medicinal plants as alternatives with minimal side effects, easy accessibility, and excellent compatibility, further clinical trials and standardization of medicinal plants are imperative for drug discovery [16]. However, there remains a gap in our understanding regarding the antimicrobial effects of aqueous extracts of *C. sinensis* against common pathogens such as *Escherichia coli* MTCC443, *S. aureus* MTCC96, *Pseudomonas aeruginosa* MTCC741, and *Salmonella typhi* MTCC733. Therefore, this study aims to fill this gap by evaluating the antimicrobial properties of aqueous leaf extracts of *C. sinensis* against these specific pathogens.

MATERIALS AND METHODS

Tea sample collection

One sample of packaged and open forms of green and black tea containing *C. sinensis* leaves was purchased from local tea shops in New Delhi.

Preparation of aqueous extract of *C. sinensis* tea leaves

Aqueous extracts of *C. sinensis* tea (green and black, packaged and open) were prepared by soaking 10 g of dry powdered leaves in sterile distilled water (100 mL) in a reagent bottle for 30 minutes. The extract was then filtered through Whatman filter paper No.1 and stored in amber-coloured reagent bottles at 4°C for further use.

Procurement of test pathogens

The pathogens used in the study were procured from the FICCI Research and Analysis Centre (FRAC), New Delhi. Bacterial strains *S. aureus* MTCC96, *S. typhi* MTCC73, *E. coli* MTCC443 and *P. aeruginosa* MTCC741 were used in the study and maintained by subculturing them on nutrient agar at regular intervals.

Antimicrobial (AM) analysis using agar-well diffusion test

The AM potential of *C. sinensis* aqueous extract (open and packaged green and black tea leaves) was conducted in the laboratory using the agar-well diffusion method. Aliquots of 500 µL of 24-hour-old broth culture (exponential phase



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of culture) were spread over the dried surface of a Muller-Hinton agar plate to ensure an even distribution of bacterial inoculums. The plates were left undisturbed for 5-10 minutes to allow for any excess surface moisture to be absorbed before making wells. Wells of about 0.6 mm diameter were made on agar plates using a sterile cork borer. A 100 μ L aliquot of the tea leaf extract (green and black) was then introduced into the wells. Petriplates were incubated at 37°C for 24 hr to assess bacterial growth, and results were recorded[17].

Determination of Minimum Inhibitory Concentration (MIC)

The MIC of aqueous tea leaf extract was evaluated by inoculating 1 mL of test bacterial strains into 10 mL of sterile nutrient broth in test tubes containing increasing concentrations (200, 400, 600, 800, 1000, 1200, 1400, and 1600 μ L) of aqueous leaves extract. The contents of the tubes were subjected to gentle shaking for proper mixing of the bacterial broth with the extract. The test tubes were incubated at 37°C for 24 hours. A tube without the test organism was kept as a control. The visual turbidity of the tubes was observed before and after the inoculation to determine the MIC value [18].

Statistical Analysis

The AM activity of green and black tea leaves aqueous extract was expressed as mean \pm standard deviation (SD). The comparison of the AM activity of aqueous extracts of packaged and open green and black tea leaves against each test bacteria was evaluated through an independent t-test. The comparison of antimicrobial activities of packaged and open green tea and black tea extract against *S.aureus* MTCC96, *S.typhi* MTCC73, *E.coli* MTCC443 and *P.aeruginosa* MTCC741 was evaluated by applying one-way analysis of variance (ANOVA).

RESULTS

Antimicrobial Activity of Tea Extracts

The study revealed potent AM activity in the aqueous extract of *C. sinensis*, confirming its efficacy against microbial infections. The AM activity was assessed by measuring inhibition zones formed around wells. After 24 hours of incubation, all four aqueous tea extracts displayed inhibition zones against selected pathogenic strains. Green tea consistently exhibited higher AM activity compared to black tea in all cases. Specifically, green tea (packaged) showed maximum inhibition against *P. aeruginosa* MTCC741, while black tea (packaged) demonstrated minimum inhibition against *S. aureus* MTCC96 and *E. coli* MTCC443. The diameter of inhibition zones for packaged green tea ranged from 22.8 \pm 1.06 mm to 23.6 \pm 0.67 mm, while for packaged black tea, it ranged from 18.8 \pm 0.73 mm to 21.75 \pm 1.34 mm (Table 1). Open green tea displayed inhibition zones ranging from 20.7 \pm 0.42 mm to 23.6 \pm 0.70 mm, whereas open black tea exhibited zones ranging from 9.2 \pm 0.63 mm to 11.2 \pm 0.52 mm against all four studied pathogenic bacterial strains (Table 1). Both green and black tea demonstrated significant AM activity ($P < 0.001$) against all the tested pathogens, while green tea showed more significant inhibition, particularly against *P. aeruginosa*. Packaged green tea exhibited significantly higher AM activity ($P < 0.001$) compared to packaged black tea; a consistent trend was observed in the comparison between open green tea and open black tea (Table 1).

Determining the MIC of Aqueous Tea Extracts

A MIC test was conducted to ascertain the lowest concentration of green tea and black tea capable of inhibiting the growth of selected pathogens. Turbidity in the growth medium indicated the presence of the test bacterial strain, and the MIC represented the lowest concentration at which no visible growth occurred. Results showed that the MIC of packaged green tea was 400 μ g/mL for *E. coli* MTCC443 and *S. aureus* MTCC96, and 600 μ g/mL for *P. aeruginosa* MTCC741 and *S. typhi* MTCC733. Packaged black tea exhibited MICs of 600 μ g/mL for *P. aeruginosa* MTCC741 and *S. typhi* MTCC733, and 800 μ g/mL for *E. coli* MTCC443 and *S. aureus* MTCC96. In the case of open green tea, the MIC was 400 μ g/mL for *P. aeruginosa* MTCC741 and 800 μ g/mL for the remaining three bacterial strains. The open form of black tea demonstrated MICs of 1200 μ g/mL for *P. aeruginosa* and 1400 μ g/mL for the other three strains, as shown in Table 2.





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DISCUSSION

The findings of the present study attribute the presence of different bioactive compounds in green and black tea, which are presumed to possess AM action against the studied pathogens. The major proportions of bioactive are comprised of polyphenols, as reported earlier by Mbata et al. [19]. Various polyphenolic compounds such as epigallocatechin gallate, catechins and theaflavins are recognized as the microbiologically active molecules present in both green and black tea [20][21][22]. A study conducted by Shetty and co-workers demonstrated that Japanese green tea, Chinese tea and black tea inhibited the growth of several bacteria responsible for diarrheal diseases, including *Vibrio cholera* and *S. typhi* [21]. The AM efficacy of boiled water tea extract and organic solvent extract was assessed against a range of bacterial strains including *E.coli* (EPEC P2 1265), *Yersinia enterocolitica* C770, *S. typhi*, *S. typhi* Ty2a, *S. typhimurium* 1402/84 and *Shigella dysenteriae* [23]. Results indicated that both green and black tea extracts significantly inhibited bacterial growth across all tested strains. However, the inhibitory concentration required for green tea extract was lower than that of black tea extract. Notably, *S. typhi* Ty2a exhibited maximum sensitivity, while *Y. enterocolitica* C770 demonstrated greater resistance to the tea extracts. Combining the commercially available antibiotic chloramphenicol at a concentration of 2.5 µg/ml (MIC 5 µg/ml) with 5.094 mg/ml of black tea extract (MIC 9.089 mg/ml) effectively inhibited the growth of *S. dysenteriae*. Other antibiotics such as gentamicin, nalidixic acid, and methicillin along with tea extract were also exhibited AM activity against the tested strains [24]. Furthermore, green tea demonstrates various antibacterial activities, restraining bacterial growth, and exhibiting synergy with β-lactam antibiotics. It was noted that employing tea extracts alongside different antibiotics enhanced the sensitivity of bacterial isolates that were resistant to most antibiotics when used alone [25].

Additionally, it was noted that green tea augmented the bactericidal activity of all tested antibiotics by suppressing the production of β-lactamases. Radji et al. reported the AM activity of Indonesian water-soluble green tea extract, which further proved to be beneficial in combating emerging drug-resistant clinical isolates such as methicillin-resistant *S. aureus* and multi-drug-resistant *P. aeruginosa* [26]. Furthermore, methanol and water extracts of *C. sinensis* tea were demonstrated to inhibit the growth of *Listeria monocytogenes* [19]. Moreover, a combination of green tea extract and penicillin G exhibited inhibitory effects on the growth of *E. coli* ATCC 25922 and *S. aureus* ATCC 25923 compared to penicillin G alone [27]. The AM effectiveness of plant extracts relies on the presence of various secondary metabolites, including hydroxyl groups, on active constituents considered as AM agents. It is reported that chemicals implicated in AM activity typically belong to diverse groups such as flavonoids, alkaloids, saponins, and polyphenols [28]. Green tea leaves comprise of numerous polyphenolic compounds which possess distinct properties for combating the harmful effects of cell proliferation. Green tea is a chemotherapeutic option and is a natural alternative to combat antibiotic-resistant pathogens [29][30]. The findings revealed greater AM activity in packaged green and black tea leaf extracts against all four tested pathogens, with their MIC values proving more effective against *S. aureus*, *S. typhi*, *P. aeruginosa*, and *E. coli*. These values were lower than those of open green and black tea leaf extracts. Aligiannis et al. proposed a classification of plant extracts based on MIC values: strong inhibition (MIC < 500 µg/mL), moderate inhibition (600 µg/mL < MIC < 1500 µg/mL), and low inhibition (MIC > 1600 µg/mL) [31]. According to this classification, aqueous extract of the packaged green tea leaves demonstrated strong inhibitory activity against all tested bacteria, while open black tea exhibited low inhibition. Tiwari et al. observed significant differences in MIC values (ranging from 9.089 to 94.61 mg/ml) of tea extract against different bacterial strains, including *S. typhi*, with MIC values ranging from 79.56 to 91.98 mg/mL [20]. However, Mbata et al. reported MICs of 0.26 and 0.68 mg/mL for methanolic and aqueous extracts of *C. sinensis* leaves against *L. monocytogenes* [19]. Thus, from the study it is indicated that the aqueous extract obtained from *C. sinensis* leaves presents a promising natural source of antimicrobial agents against *S. aureus* MTCC96, *S. typhi* MTCC73, *E. coli* MTCC443 and *P. aeruginosa* MTCC741.





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CONCLUSION

In summary, widely consumed globally, black and green tea (*C. sinensis*) possess antimicrobial and health-enhancing qualities. Consequently, their antimicrobial properties could offer valuable supplements to the existing array of antibiotics. Hence, it suggests that both green and black tea extracts could serve as potent antibacterial agents against *S. aureus*, *S. typhi*, *E. coli* and *P. aeruginosa*, with packaged green tea being the preferred choice.

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Table 1: Assessment of antimicrobial activity of aqueous extract of green and black tea (open and packaged) by well diffusion method

Bacterial Stains	Packaged		Open	
	Green Tea	Black Tea	Green Tea	Black Tea
	Zone of inhibition in mm ± S.D.			
<i>S. aureus</i> MTCC96	22.8±1.06	19.1±0.81	20.7±0.42	9.20±0.63
<i>E. coli</i> MTCC443	23.1±0.47	19.0±0.85	20.7±0.60	11.2±0.52
<i>P. aeruginosa</i> MTCC741	23.6±1.38	21.8±1.34	23.5±0.70	10.2±0.55
<i>S. typhi</i> MTCC733	23.6±0.67	18.8±0.73	20.7±0.58	9.55±0.60



**Barkha Bhatnagar et al.,****Table 2: MIC of green and black teas (open and packaged) extracts against test pathogens.**

Test organisms	Minimum Inhibitory Concentration($\mu\text{g/mL}$)			
	Packaged Green tea	Packaged Black tea	Open Green tea	Open Black tea
<i>E. coli</i> MTCC443	400	800	800	1400
<i>S. aureus</i> MTCC96	400	800	800	1400
<i>P. aeruginosa</i> MTCC741	600	600	400	1200
<i>S. typhi</i> MTCC733	600	600	800	1200





Standardization and Evaluation of Value - Added Choco-bar for School Children using Samai - Vallarai Powder (SVCP)

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ABSTRACT

Samai (*Panicum sumatrense*) is known for its health benefits because it is gluten free, rich in iron, calcium and phosphorous. Vallarai leaves (*Centella asiatica*) improves mental characteristics by preventing cell damage, acts as a memory enhancer and helps to improve iron & calcium for children. Many studies revealed unhealthy snacking habit among the children which has adverse effects on them like childhood obesity, early mensuration, anaemia, nutritional deficiencies, and poor mental health status. "Objective of the study is to standardize Samai-Vallarai composite powder (SVCP), to develop value added product from SVCP, to evaluate the organoleptic acceptability, to analyse the nutrients, phytochemical properties, physiochemical properties and shelf life of the developed product. Samai-Vallarai was sundried and grounded into fine powder. SVCP was formulated into three different proportions and developed a value-added Choco-bar in three variations V1, V2 and V3. The developed product was organoleptically evaluated using 5-point hedonic scale with control sample. Selected sample and SVCP was analysed for its nutrients and shelf life. The results indicated that variation V2 was highly accepted with mean score of (4.37 ± 0.490) compared with control sample score (3.50 ± 0.509) , V1 and V3. Nutrient analysis revealed more fat and carbs in SVCP Choco-bar than SVCP whereas protein, fiber, calcium and iron was higher in SVCP than SVCP Choco-bar. Phytochemical analysis revealed greater antioxidant and total phenolic properties in SVCP than SVCP Choco-bar. The physiochemical analysis revealed that the pH and TSS was high in SVCP Choco-bar than SVCP and acidity was found to be same (0.06%) in both. The microbial analysis revealed 0.55×10^5 , 1.69×10^5 , 2.87×10^5 , and 3.42×10^5 cfu/ml during the first, second, third, and fourth days for



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four weeks respectively. This study observed that SVCP was a high source of phenols, antioxidants, proteins, fiber, iron and calcium. Considering poor eating habits of kids, this makes it a better choice for making snacks for them. SVCP may be used as a basic ingredient in a wide range of culinary items like the SVCP Choco bar which is nutritious and have high health benefits towards many disease conditions such as diabetic, cataract, cancer and helps to improve cardiac health.

Keywords: Millets, Vallarai, anaemia, memory enhancement, iron, antioxidant, healthy snack.

INTRODUCTION

Indian millets are a class of highly nutritious, drought-tolerant plants that are mostly cultivated in the country's arid and semi-arid areas. Because it has more protein, vitamins, and minerals than wheat and rice, it is a better nutritious choice. They are also low in glycaemic index and gluten-free, which makes them perfect for those who have diabetes or celiac disease [1]. The tribe Paniceae, sub-family Panicoideae, and family Poaceae are native to little millet. Common names for little millet (*Panicum sumatrense* L.) include samai, samo, morai, vari, and kutki. It is cultivated in India in various agroecological conditions [2]. A recent study on small millet revealed that its higher concentration of dietary fiber causes it to display a hypoglycaemic impact, which is one of the factors leading to its low glycaemic index [3]. It plays a vital function in the diet by contributing a substantial number of phytochemicals and antioxidants [4]. It is a fantastic millet that works well for all age groups. It cures various gastrointestinal issues and aids in the prevention of constipation. The complex carbohydrates in it break down gradually, making it ideal for those with diabetes and obesity patients. Nutraceutical elements including phenols, tannins, and phytates are among the many nutrients that Indian pennywort or Vallarai keera contributes to the diet [5]. The plant family Apiaceae (previously Umbelliferae) and subfamily Mackinlayoideae include *Centella Asiatica*, often known as Little Millet. This plant thrives in marshy places found in tropical and subtropical climates worldwide. Native to the Asian subcontinent, it is found in the tropical parts of Southeast Asia, Malaysia, the Solomon Islands, and certain temperate regions of China, Japan, Korea, and Taiwan. The extensive history of *C. asiatica*'s medical usage spans from the first indications of its utilization by the Indian physician Sushruta to the traditional herbal medicine systems found in Asian and African nations [6].

The significance of *C. asiatica* in the Ayurvedic tradition as a "medhyarasayana" plant—that is, a herb with restorative properties that enhance memory, guard against cognitive decline, and enhances brain function [7]. Phytochemical substances such as ursolic acid, myrcene, rutin, sitosterol, eugenol acetate, arjunolic acid, asiatic acid, asiaticoside, brahminoside B, castilllicetin, castilliferol, catechin, chavicol, and corosolic acid [8]. For hundreds of years, *Centella asiatica* has been used in traditional medical systems to treat a wide range of illnesses, such as dementia, hypertension, sleeplessness, infectious infections, and asthma. The Ayurvedic tradition has long acknowledged the plant's ability to enhance brain function. Numerous preclinical investigations conducted in the last ten years have validated these effects in the setting of age-related cognitive decline, both pathological and normal [9]. It is well known that CA—a cognitive and antioxidant—can boost focus and attention span, fight aging, and revitalize the brain and nervous system. It has sedative, antidepressant, antiepileptic, anti-inflammatory, wound-healing, and radioprotective qualities as well [10]. When it comes to supporting changes in the brain and cognitive processing, linear bone development and mineralization, body composition, and other organ systems, nutrition is essential for children during the developmental stage [11]. Numerous studies have demonstrated the negative impacts of children's unhealthy eating habits, including early menstruation, childhood obesity, juvenile diabetes, anemia, nutritional inadequacies, and poor mental health.





MATERIALS AND METHODS

Preparation of Samai-Vallarai Composite Powder (SVCP)

Fresh and high-quality Vallarai leaves were chosen from Chennai's Koyampedu market to make the Samai-Vallari Composite. Freshness, colour, and firmness were the determining factors in the selection of Vallarai leaves. Dried, dark-coloured, and dull-looking Vallarai leaves were rejected. Fresh vallarai leaves obtained from local market were washed with soft water. The leaves were then dried in direct sunlight for almost 3-4 days. To make a fine powder, dried leaves were ground in a mixer, and kept in airtight aluminium zip-lock bags until use. The samai rice was purchased from a nearby grocery in Chennai. The highest-quality millets were chosen from a batch of aged, organic, unpolished, and uniformly sized yellow grains. New, shiny millets with vibrant colours were turned down. Small millets were cleaned, then dry-roasted in a skillet till the smell of samai emerged. After being cooled, the little millet was roasted and then ground into flour using a mixer to produce a fine powder, the millet flour was sealed in an airtight container and kept until use. Lastly, three distinct proportions (V1, V2, and V3) with ratios of 25%, 50%, and 75% respectively was made by mixing vallarai leaves dry powder with millet powder (Figure 1).

Preparation of SVCP Choco-bar

To formulate the SVCP Choco-bar, 100g of SVCP was dry-roasted for a few seconds and set away. Next, 50g of jaggery, 25ml of coconut oil, and 100 g of dark chocolate compound was melted using the double boiling technique. This was mixed with roasted SVCP. After being moved to the mould, 10g of nuts (almonds and cashews) were topped, and the mixture was cooled for two hours at -18 degrees in the freezer. The Choco-bar from SVCP was finally demoulded (Figure 2). This was repeated three times, using SVCP variation of 25%, 50%, and 75% (V1, V2, and V3, respectively). As a control sample, a regular Choco-bar with nuts was purchased from the store. A 5-point hedonic score-card was used to evaluate the organoleptic qualities of these Choco-bars, and the evaluation was conducted by 30 semi-trained panel members [12]. The panellists evaluated the Choco-bar's quality based on a range of sensory factors, including appearance, colour, flavour, texture, taste and overall acceptability of the different variations of Choco-bar (V1, V2, and V3) and control. After an organoleptic study, variation V2 was chosen because it had the greatest overall acceptance score compared to the other two variations and the control.

Analysis of the SVCP and SVCP Choco-bar.

The selected variation V2 SVCP and SVCP Choco-bar were analyzed for nutrients, phytochemical properties, and physicochemical properties. The microbial analysis was also done for the selected products. The results obtained from the organoleptic evaluation were interpreted using statistical tools such as mean and standard deviation using SPSS software.

RESULTS AND DISCUSSIONS

Organoleptic evaluation

Based on a sensory evaluation of SVCP Choco-bar made with 25%, 50%, and 75% SVC powder, it was determined that overall acceptance of variation 2 was very good when compared to other variations and controls. Table 1 presents the mean score and standard deviation for appearance, colour, flavour, texture, taste, and overall acceptability derived from all three variations (V1, V2, and V3) and control. The texture, taste, and flavour of the Choco-bar were significantly impacted by the addition of 50% SVC powder (V2), as seen in Graph 1. Additionally, as seen in Graph 2, the variation with 50% SVCP Choco-bars added was the most acceptable.



**Priyadharshini and Indirani Kaliappan****Nutrient analysis of SVCP and SVCP Choco-bar**

A nutritional analysis of the SVCP and SVCP Choco-bar was shown in Table 2, revealing 65.01g of carbohydrates, 12.31g of protein, 2.69g of fat, 4.85g of fiber, 4.5g/L of calcium, and 2.02 g/L of iron in 100g of the powder. The nutritional composition of the SVCP Choco-bar was 68.42g carbohydrate, 10.58g protein, 12.13g fat, 1.07g fiber, 1.3 g/L calcium, and 0.6 g/L iron. In comparison to the SVCP Powder, the SVCP choco-bar contained more fat and carbs, according to this study. SVCP contained higher protein, fiber, calcium, and iron levels than SVCP Choco-bar. Next to barnyard millets, little millets are fibrous. Research indicates that 37–38% of some Kodo and small millet cultivars contain dietary fiber, which is the main component [13].

Phytochemical analysis of SVCP and Variation (V2) SVCP Choco-bar

The chemical analysis of the SVCP and Choco-bar was shown in Table 3, which showed that 100g of the powder contained 324.58 mg/g of total phenols and 5579.88 µg of total antioxidants. SVCP Choco-bar has a total antioxidant content of 3186.18 mg and 146.13 mg/100 g. According to this study, SVCP is a great source of high levels of phenolic properties and antioxidants when compared to SVCP Choco-bar; the total antioxidant analysis (TAA) revealed these high levels in SVCP. With SVCP Choco-bar's functional qualities and suitability for mixing its high concentration of antioxidant components with other ingredients, it can be made into many confections utilising a range of methods. One study finding suggested that applying heat could increase or decrease Total Antioxidant Activity.

Physiochemical analysis of SVCP and V2 SVCP Choco-bar

The physiochemical properties of the SVCP and SVCP Choco-bar were shown in Table 4, which showed that SVCP powder contained 5.6 pH, and 2 brix of TSS. SVCP Choco-bar has a pH content of 6.6 and 10 brix of TSS. According to this study, SVCP Choco-bar is a great source of high levels of pH and TSS when compared to SVCP powder. Both powder and Choco-bar have an acidity level of 0.06% respectively.

Shelf-life analysis

As a result, the microbiological count was performed on the first, second, third, and fourth days of the respective four weeks. Between the first day of the first week and the thirty-first day, the total number of plates counted was 0.55×10^5 , 1.69×10^5 , 2.87×10^5 , and 3.42×10^5 cfu/ml, respectively. Graph 3 shows that even though it was locked with an aluminium zip lock cover for about four weeks, the total number of plates rose from day one to day thirty. Therefore, another innovative preservation or packaging technique is required to stop microbial development and extend the shelf life to more than 3 months.

CONCLUSION

Samai-Vallarai Composite Powder (SVCP) was formulated and used to create a value-added Choco-bar for the current investigation. It emerged that SVCP was a high source of phenols, antioxidants, proteins, fiber, iron and calcium. Considering how poorly kids eat, this makes it a better choice for making snacks for them. Like the SVCP Choco bar, SVCP may be used as a basic ingredient in a wide range of culinary items. Because of its potential health benefits, including memory enhancement, antidiabetic, anti-hyperlipidaemic, anemia prevention and treatment, bone health and development, constipation prevention, aging prevention, improved heart health, and anticancer action due to antioxidant properties, this composite mixture is suitable for children as well as all other age groups.

"ALWAYS BE RIGHT TO EAT RIGHT": Raising children's awareness of the benefits of eating Indian millets or little millets along with vallarai leaves will help prevent chronic illnesses like diabetes and cardiovascular disease, as well as work toward making our nation diabetes-free [13]. Thus, always consider eating healthy; increase the amount of millet than the amount of rice and wheat.

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Table 1: Mean organoleptic scores of controls and SVCP Choco-bar

ORGANOLEPTIC PROPERTIES	Mean score of variations			
	CONTROL	V1	V2	V3
Appearance	3.93 ± 0.254	2.13 ± 0.681	4.37 ± 0.490	3.03 ± 0.414
Colour	3.50 ± 0.509	1.60 ± 0.675	4.40 ± 0.480	2.50 ± 0.509
Flavour	3.93 ± 0.254	2.33 ± 0.758	4.40 ± 0.480	3.03 ± 0.414
Texture	3.87 ± 0.346	2.27 ± 0.828	4.40 ± 0.480	2.97 ± 0.490
Taste	3.93 ± 0.254	2.30 ± 0.750	4.40 ± 0.480	3.03 ± 0.414
Overall acceptability	3.50 ± 0.509	2.13 ± 0.681	4.37 ± 0.490	2.97 ± 0.490





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Table 2: Nutrient analysis of (V2) SVCP Choco bar and SVCP powder

Nutrients	Variation (V2) SVCP Choco-Bar	Variation (V2) SVCP (powder)
Carbohydrates (g)	68.42	65.01
Protein (g)	10.58	12.31
Fat (g)	12.13	2.69
Fiber (g)	1.07	4.85
Calcium (g/L)	1.3	4.5
Iron (g/L)	0.6	2.02

Table 3: Phytochemical analysis of SVCP (powder) and SVCP Choco-bar

Phytochemical properties	SVCP (Powder)	SVCP Choco-bar (V2)
Total Antioxidant Activity mg/g	5579.88	3186.18
Total Phenols mg/100g	324.58	146.13

Table 4: Physiochemical properties of SVCP (powder) and SVCP Choco-bar variation

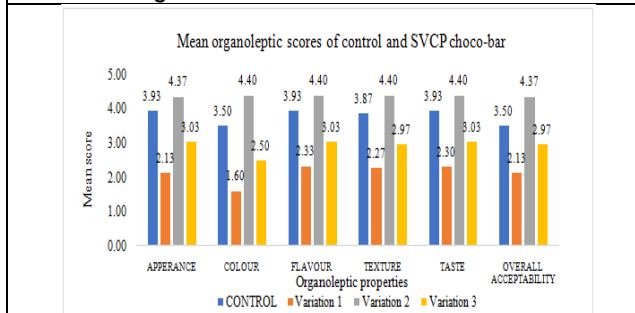
Physiochemical properties	SVCP	SVCP Choco-bar (V2)
pH	5.6	6.6
Acidity %	0.06	0.06
TSS (Brix)	2	10



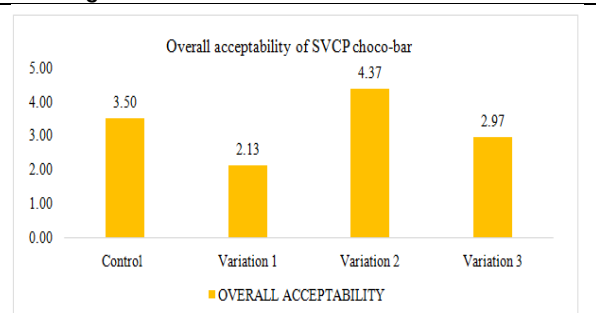
Figure 1: Three variations of SVCP



Figure 2: V2 Variation of SVCP Choco-bar



Graph 1: Mean organoleptic scores of controls and SVCP Choco-bar

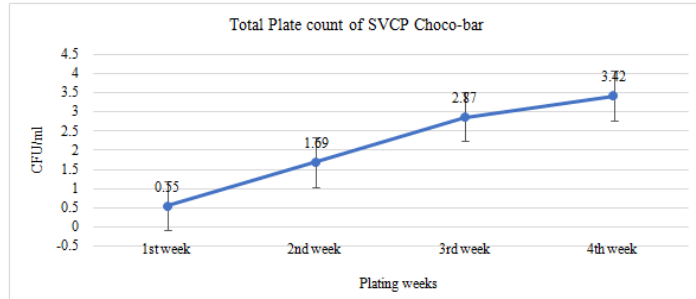


Graph 2: Overall acceptability of SVCP Choco-bar





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Graph 3: The total Plate Count of the SVCP Chocolate





Comprehensive Management of Shushkakshipaka w.s.r. to Dry Eye Syndrome – A Single Case Study

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ABSTRACT

Dry eye disease is a global issue that continues to grow in terms of the numbers of people it affects and the impact it has on sufferers. It is one of the most prevalent issues and causes of referrals to ophthalmology clinics. The signs and symptoms of dry eye can be correlated to Shushkakshipaka which is one among the Sarvagata netrarogas affecting all parts of eye as explained in Ayurvedic texts. This is a single case study of dry eye, treated according to the treatment principles of Shushkakshipaka as explained in Ayurvedic classics Present study is a case report of 23 years old male patient who approached Shalaky Tantra OPD of Parul Ayurved Hospital, Vadodara, Gujarat with feeling of dryness on both eyes associated with headache, irritation and blurring of vision since 4 months. He was thoroughly examined and diagnosed as Shushkakshipaka. He was treated with Deepana Pachana, Kosthashodhana, Aschyotana along with Snehapana followed by three sittings of Netra Parisheka, Akshi Tarpana, Nasya, as mentioned in the classics. Patient showed marked improvement subjectively and in diagnostic tests like Schirmer-I test, Tear film Break up time and Fluorescein staining in both eyes. The dry eye disease can be considered as Shushkakshipaka and can be treated according to its treatment principles.

Keywords: Shushkakshipaka, Tarpana, Nasya, Parisheka, Aschyotana, Sarvagata netraroga.





INTRODUCTION

Dry Eye is a multifactorial disorder due to inflammation of the ocular surface, lacrimal gland, meibomian gland dysfunction and neurotrophic deficiency.[1]It is a condition in which a person doesn't have enough quality tears to lubricate and nourish the eye. Tears are necessary for maintaining the health of the ocular surface and for providing clear vision. Various environmental factors such as air dryness, pollution, global warming, smoke, allergens, systemic diseases, contact lens wear and age are contributing to more cases of dry eye.[2-5]The disease has increased in recent years with the advent of monitors and prolonged use of computers due to over exposure to visual displays. Similar clinical manifestation of Dry Eye can be observed in a disease called as Shushkakshipaka. It is a Vata- PittajaVyadhi having symptoms like Gharsha (foreign body sensation), Vishushkatwama (feeling of dryness in eyes),Kricchronmeela-Nimeelanama (difficulty in opening the eyes), Rukshadarunavartma,Toda (Pricking sensation), Daha (Burning sensation), Raga (redness) [6] In Ayurveda classics, specific treatment has been mentioned for Shushkakshipaka such as Snehapana Tarpana,Nasya and Pariseka.[7]

MATERIALS AND METHODS

Case Report

A fully conscious, normal oriented male patient, aged 23 years, consulted Shalakya Tantra OPD of ParulAyurved Hospital, Vadodara on 20-12-2023 complaining of irritation, pain, feeling of dryness in both eyes along with frontal headache for 4 months. He was diagnosed as a case of Dry Eye. History of present illness: The subject was apparently normal 4 months ago. He gradually developed dryness of bilateral eyes, irritation and pain. It was associated with Frontal headache and blurring of vision in both the eyes. But gradually the severity of symptoms increased and he approached Shalakya Tantra OPD of Parul Ayurved Hospital, Vadodara. History of past illness: No past history of any systemic diseases like Asthma, Hypertension or Diabetes. No Surgical history.

Family History: Nothing Significant.

Personal History:

Appetite: Good

Bowel: Once a day / Regular

Micturition: 4-6 times/ day

Sleep: Sound

Habits: None

Occupation: Engineering student (Computer Science)

Ashta Sthana Pareeksha:

Nadi: 74/min

Mutra: 4-6 times/day

Mala: **Parkrutha**

Jihwa: Alipta

Shabda: Prakrutha

Sparsha: Prakrutha

Drik: Shuskatha

Akriti: Madhyama

Clinical findings: He was afebrile. The pulse rate was 74/minute. Respiratory Rate was 16/minute and Blood Pressure was 110/70mmHg. Systemic examination was within normal limits.

Ophthalmic Examination:



**Shalaka More and Manjiri Keskar****THERAPEUTIC INTERVENTION**

Deepana Pachana (appetizer & digestant) was done with HingwasthakChurna. [8] 6 gm of the medicine was consumed with first morsel of food, added with cow gheet twice daily for three days. Koshtashodhana (elimination of doshas and malas from koshta) in the form of Sadyovirechana (purgation) was done with Eranda Taila^[9]. 40 ml of the medicine was given with hot water at 6.00 am in the morning. Nasya was done with Anutaila. 8 drops of the Anutaila were instilled in both nostrils for the next seven days at 10.00 am^[10]. Then Tarpana was done in both the eyes with JeevanthyadiGhrita for 5 days. There was a gap of 15 days between each sitting of the treatment, during which, the patient was given Ashchyotana with JeevanthyadiGhrita 2 drops for each eye in the morning and evening. JeevanthyadiGhrita was given internally 10ml twice a day with milk. Subject was assessed 15 days after the completion of 3rd sitting of treatment.

RESULTS

The study showed marked improvement in signs and symptoms of the patient after the treatment as shown in table no. 5. There was no recurrence in signs and symptoms at the time of follow up of the patient. No adverse or unanticipated events were observed during or after the completion of study.

DISCUSSION

Shushkakshipaka is a Vata Pitta predominant vyadhi. In present case the aim of treatment was to achieve Vata Pittahara and Brumhana karma to eyes. HingwasthakChurna was given at first for Pachana of Amadosha. In order to improve the body's absorption of the medications, sadyovirechana was administered to cleanse the koshta. After Kaya Shodhana and Sansarjan karma UrdhwajatruShodhana was planned with Anutail Nasya, as it is indicated in Shushkakshipaka and UrdhwaJatrugata vikaras^[11]. Seka was selected as sthanikamrudusweda. Madhura Rasa and Vipaka, Sheeta Veerya, Snigdha and Guru Guna, Vatapittahara and Rasayana^[12] properties of YastimadhuKsheerapaka, administered as netraseka helps in reducing the inflammation thereby does the healing of conjunctival and corneal epithelial defects. Tarpana with JeevanyadiGhrita was adopted for 5 days. Balya, Rasayana, Drishtivardhaka^[13] properties of JeevanyadiGhrita helps in maintaining the lipid layer of tear film which reduces the evaporation of aqueous layer of tear film. Thus maintains the longer lubrication of the ocular surface thereby relieving dryness, painful blinking of the eyes and foreign body sensation. The internal administration of Jeevanthyadighrita will help in nourishment of depleted dhatus. Aschyotana with Jeevanthyadighrita will help in proper movements of the eyelids, reduces burning sensation, discoloration and irritation of eyes caused due to the dry ocular surface.

CONCLUSION

Dry eye is a very common clinical condition of eye. In which homeostasis between the three layers of tear film is lost. As per Ayurveda, Snehana and Brumhanachikitsa is essential for maintaining the homeostasis and stabilising the tear film. Thus, it can be concluded that, by adapting the above therapeutic procedures, the further vitiation of Vata and Pitta doshas can be prevented and functions of different structure of the eye which are responsible for proper lubrication will be restored.

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Table 1: Slit lamp examination

Ocular Structures	Right Eye	Left Eye
Ocular Adnexa	No abnormalities detected	No abnormalities detected
Conjunctiva	Congestion present	Congestion present
Sclera	No abnormalities detected	No abnormalities detected
Cornea	Clear	Clear
Anterior chamber	Normal depth	Normal depth
Pupil	Round, Regular, Reactive	Round, Regular, Reactive
Lens	No abnormalities detected	No abnormalities detected
IOP	14.6 mm Hg	14.6 mm Hg

Table 2: Visualacuity

Visual acuity	Without Spectacles			With Spectacles		
	BE	OD	OS	OD	OS	BE
Distant vision	6/9	6/12	6/9	6/6	6/6	6/6
Near vision	N6	N6	N6	-	-	-

Table 3: Diagnostic Test

Test Name	Right Eye	Left Eye
Schirmer 1Test	6 mm	8 mm
TBUT	7 sec	8 sec
Fluorescein stain	Positive	Positive





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Table 4: Treated Adopted

Treatment Given	Drug Name	Duration	Dosage
Deepana Pachana	HingwasthakChurna	3 days	6 gm
Kosthashodhana	Eranda Taila	1 day	40 ml
Netra Seka (3 sittings)	YastimadhuKsheerapaka	7 days	Sufficient quantity
Nasya (3 sittings)	Anutaila	7 days	8 drops each nostril
Tarpana (3 sittings)	JeevantyadiGhrita	5 days	30 gm

Table 5: Result

DIAGNOSTIC CRITERIA	RIGHT EYE		LEFT EYE	
	BT	AT	BT	AT
Schirmer- I test	6 mm	16 mm	8 sec	18 mm
Tear film break up time	7 sec	13 sec	8 sec	15 sec
Fluorescein staining	Positive	Negative	Positive	Negative





Phytochemical Analysis and Antimicrobial Activity of Cinnamon Oil against *Aeromonas caviae*

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ABSTRACT

This study analyzed cinnamon oil to identify its chemical composition and evaluated its antibacterial activity against *Aeromonas caviae*. The analysis revealed the presence of various classes of compounds, including acids, alkaloids, coumarins, flavonoids, phenols, quinones, steroids, tannins, terpenoids, and triterpenoids. Among the identified compounds, phenol, vanillin, (Z)-cinnamyl benzoate, and rutamarin were found to be the main constituents. Phenol exhibited disinfectant properties, vanillin had pharmaceutical applications, (Z)-cinnamyl benzoate was used in perfumes and cosmetics, and rutamarin showed potential for protecting against heart disease, diabetes, neurodegenerative diseases, and microbial/fungal infections. The antibacterial activity of cinnamon oil was investigated, and the results demonstrated a dose-dependent increase in the zone of inhibition against *Aeromonas caviae*. At higher concentrations, cinnamon oil exhibited stronger antibacterial activity than the standard antibiotic ciprofloxacin. The molecular mechanism underlying the antibacterial effects of cinnamon oil was attributed to bioactive components such as cinnamaldehyde, which disrupts bacterial cell membranes, leading to membrane damage and inhibition of bacterial growth. Furthermore, cinnamon oil may



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interfere with bacterial enzymes and metabolic processes. However, the exact mechanism of its antibacterial activity against *Aeromonas caviae* may involve additional factors that warrant further investigation.

Keywords: *Aeromonas caviae*, cinnamon oil, well diffusion method, GC-MS

INTRODUCTION

Phytochemical analysis plays a crucial role in the field of natural product research, as it involves the identification and characterization of bioactive compounds present in plant extracts [1-11]. These compounds possess diverse biological activities and have been extensively studied for their potential therapeutic applications [12]. One such plant extract that has gained considerable attention is cinnamon oil, derived from the bark of *Cinnamomum* species [13-15]. Cinnamon oil is known for its distinct aroma and flavor, and it has been traditionally used for various medicinal purposes [16-19]. In recent years, there has been a growing interest in exploring the phytochemical composition and biological properties of cinnamon oil. The objective of this study is to conduct a comprehensive phytochemical analysis of cinnamon oil and evaluate its antimicrobial activity against *Aeromonas caviae*. *Aeromonas caviae* is a Gram-negative bacterium commonly found in aquatic environments and is known to cause a range of infections in humans, including gastroenteritis, wound infections, and septicemia [20]. The emergence of antibiotic resistance among *Aeromonas* species has become a significant concern, necessitating the search for alternative antimicrobial agents.

Specifically, this research aims to

Analyze the phytochemical composition of cinnamon oil using various analytical techniques such as gas chromatography-mass spectrometry (GC-MS). This analysis will provide insights into the presence and abundance of different classes of bioactive compounds in cinnamon oil, including phenolic compounds, terpenoids, and essential oils. Determine the antimicrobial activity of cinnamon oil against *Aeromonas caviae* through well-established microbiological methods. The antimicrobial activity will be compared to standard antibiotics to evaluate its potential as a natural alternative or adjunct therapy. Investigate the mechanisms of action underlying the antimicrobial activity of cinnamon oil. This will involve studying its effects on bacterial cell viability, membrane integrity, and the production of virulence factors by *Aeromonas caviae*. Understanding the mode of action will provide insights into the potential targets of cinnamon oil and its suitability as an antimicrobial agent. By conducting a comprehensive phytochemical analysis and evaluating the antimicrobial activity of cinnamon oil against *Aeromonas caviae*, this study aims to contribute to the growing body of knowledge on natural products with potential therapeutic applications. The findings of this research could have implications for the development of new antimicrobial agents to combat *Aeromonas* infections and serve as a foundation for further investigations into the bioactivity of cinnamon oil.

MATERIALS AND METHODS

All the chemicals, solvents, and essential oils used in investigations were obtained from Aromax trading PVT Ltd, Chennai, India as a standard chemical supplier.

Qualitative Phytochemical Analysis

Phytochemical screening of cinnamon oil was carried out according to the method of Mishra et al. (2014) [21].

Test for Acids

Million's Test: To 1.0 ml oil, five drops Million's reagent was added, heated on a water bath for 5 min. and allowed to cool, followed by addition of 1% sodium nitrite solution. Formation of red colour indicates the presence of acids.





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Test for Alkaloids

Mayer's Test: To 2.0 ml oil, 2.0 ml concentrated hydrochloric acid followed by few drops Mayer's reagent were added. Presence of green colour or white precipitate indicates the presence of alkaloids.

Test for Anthocyanin and Betacyanin

Sodium Hydroxide Test: To 2.0 ml oil, 1.0 ml 2N sodium hydroxide was added and heated for 5 min. at 100°C. Formation of bluish green colour indicates the presence of anthocyanin and yellow colour shows the presence of betacyanin.

Test for Carbohydrates

Molisch's Test: To 2.0 ml oil, 1.0 ml Molisch's and few drops of concentrated sulphuric acid were added. Formation of purple or reddish ring indicates the presence of carbohydrates.

Test for Cardiac Glycosides

Ferric Chloride Test: To 0.5 ml oil, 2.0 ml glacial acetic acid and few drops 5% ferric chloride were added. This was under layered with 1.0 ml concentrated sodium hydroxide. Formation of the brown ring at the interface indicates presence of cardiac glycosides.

Test for Coumarins

Sodium Hydroxide Test: To 1.0 ml oil, 1.0 ml 10% sodium hydroxide was added. Formation of yellow colour indicates presence of coumarins.

Test for Flavonoids

Sulphuric Acid Test: 1.0 ml oil was treated with few drops of concentrated sulphuric acid and observed for the formation of orange colour, which indicates the presence of flavonoids.

Test for Glycosides

Sulphuric Acid Test: To 2.0 ml oil, 1.0 ml glacial acetic acid, 5% ferric chloride and few drops concentrated sulphuric acid were added. Presence of greenish blue colour indicates the presence of glycosides.

Test for Phenols

Ferric Chloride Test: To 1.0 ml oil, 2.0 ml distilled water, followed by few drops 10% ferric chloride were added. Formation of blue or green colour indicates presence of phenols.

Test for Proteins

Ninhydrin Test: To 2.0 ml oil, few drops 0.2% ninhydrin was added and heated for 5 min. Formation of blue colour indicates the presence of proteins.

Test for Quinones

Sulphuric Acid Test: To 1.0 ml oil, 1.0 ml concentrated sodium hydroxide was added. Formation of red colour indicates the presence of quinones.

Test for Saponins

Foam Test: To 1.0 ml oil, 5.0 ml distilled water was added and shaken well in a graduated cylinder for 15 min lengthwise. Formation of 1.0 cm layer of foam indicates the presence of saponins.

Test for Starch

Iodine Test: To 2.0 ml oil, few drops iodine solution was added. Formation of blue-purple colour indicates the formation of starch.





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Test for Steroids

Salkowski Test: To 5.0 ml oil, 2.0 ml chloroform and few drops concentrated sulphuric acid were added. Formation of red colour indicates the presence of steroids.

Test for Tannins

Ferric Chloride Test: To 1.0 ml oil, 2.0 ml 5% ferric chloride was added. Formation of dark blue or greenish black indicates the presence of tannins.

Test for Terpenoids

Sulphuric Acid Test: To 0.5 ml oil, 2.0 ml chloroform was added and to this, concentrated sodium hydroxide was added carefully. Formation of red brown colour at the interface indicates presence of terpenoids.

Test for Triterpenoids

Liebermann - Burchard's test (LB test): To 1.5 ml oil, few drops Liebermann - Burchard's reagent (acetic anhydride and concentrated sodium hydroxide) was added. Formation of blue green colour indicates presence of triterpenoids.

GC-MS Spectral Analysis

GC-MS spectral analysis was carried out to determine the presence of aromatic compounds in the essential oil samples. The model of the GC-MS used for mass spectral identification was an Agilent 7890 interfaced with a 240-mass selective detector and an ion trap. Interpretation of GC-MS was conducted using the database of the National Institute of Standard and Technology (NIST) having more than 62,000 patterns. The spectrum of the unknown component was compared with the spectrum of the known components stored in the NIST library. The name, molecular weight, and structure of the components of the test materials were ascertained.

Antibacterial activity

Antimicrobial assay of extracts of different plants was performed by agarwell diffusion method in Mueller Hinton Agar (MHA) plates. The test organisms were inoculated in Nutrient broth and incubated overnight at 37°C to adjust the turbidity to 0.5McFarland standards giving a final inoculum of 1.5×10^8 CFU/ml. MHA plate was lawn cultured with standardized microbial culture broth. Cinnamon oil of 5,10,15,20 and 25 $\mu\text{g}/\mu\text{l}$ concentration were prepared in Dimethyl Sulfoxide (DMSO). Four wells of 6 mm were bored in the inoculated media with the help of sterile cork-borer (6 mm). Positive control(Ciprofloxacin 300 mcg was used. It was allowed to diffuse for about 30 minutes at room temperature and incubated for 18-24 hours at 37°C. After incubation, plates were observed for the formation of a clear zone around the well which corresponds to the antimicrobial activity of tested compounds. The zone of inhibition (ZOI) was observed and measured in mm.

RESULTS AND DISCUSSION

Essential oils, which contribute to the distinctive scent of plants, consist of volatile compounds. These oils vary in composition, as illustrated in Table 1. For instance, cinnamon oil comprises acids, alkaloids, coumarins, flavonoids, phenols, quinones, steroids, tannins, terpenoids, and triterpenoids. The analysis of cinnamon oil through phytochemical analysis involves identifying and quantifying the different chemical compounds present. This examination has unveiled the existence of multiple compound classes, including acids, alkaloids, coumarins, flavonoids, phenols, quinones, steroids, tannins, terpenoids, and triterpenoids. Let's explore the significance of each of these compound classes. Acids, characterized by their sour taste, are organic compounds found in cinnamon oil, including varieties like cinnamic acid and benzoic acid. These acids not only add to the aroma and flavor of cinnamon oil but also harbor antimicrobial and antioxidant properties. Alkaloids, nitrogen-containing compounds, exhibit pharmacological effects and diverse biological activities, such as analgesic, antimicrobial, and anti-inflammatory properties. Examples like cinnamaldehyde and eugenol may be present in cinnamon oil. Coumarins, recognized for their sweet odor, contribute to the distinctive aroma of cinnamon oil and are associated with



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antimicrobial, anti-inflammatory, and antioxidant properties. Flavonoids, a diverse group of plant compounds, bring potential health benefits to cinnamon oil, featuring antioxidant, anti-inflammatory, and anticancer properties. Notable flavonoids in cinnamon oil, such as quercetin and kaempferol, enhance its therapeutic potential. Phenols, characterized by a hydroxyl group (-OH) attached to an aromatic ring, exhibit robust antioxidant properties, effectively scavenging free radicals in the body. Cinnamon oil encompasses diverse phenols, including cinnamic acid derivatives like cinnamaldehyde and cinnamyl alcohol. Quinones, aromatic compounds, play pivotal roles in physiological processes, serving as antioxidants or prooxidants based on the context. The quinones in cinnamon oil may play a role in its antioxidant and antimicrobial properties. Steroids, a lipid class, are vital in various biological processes, regulating cellular functions with anti-inflammatory and immunomodulatory properties. The steroids present in cinnamon oil could offer potential health benefits. Tannins, polyphenolic compounds, are recognized for their protein-binding and precipitating abilities, featuring antimicrobial, antioxidant, and anticancer properties. The inclusion of tannins in cinnamon oil may contribute to its diverse biological activities. Terpenoids, also referred to as isoprenoids, form a diverse category of compounds abundant in numerous plants, playing a pivotal role in imparting the unique aroma and flavor of cinnamon oil. Terpenoids exhibit antimicrobial, anti-inflammatory, and antioxidant activities. Triterpenoids, a specific subclass of terpenoids distinguished by their structure, have been linked to a range of biological activities, including anticancer, anti-inflammatory, and antimicrobial properties.

The triterpenoids found in cinnamon oil may contribute to its potential health benefits. In summary, the phytochemical analysis of cinnamon oil reveals a rich assortment of compounds with diverse biological activities. These compounds collectively contribute to the distinctive aroma, flavor, and potential health advantages associated with cinnamon oil, establishing it as a valuable natural product. Cinnamon oil (Figure 1) was analyzed, revealing the presence of twenty-one compounds. Key compounds identified include phenol (9.145 min), vanillin (15.223 min), (Z)-cinnamyl benzoate (16.589 min), and rutamarin (42.239 min). Phenol is recognized for its disinfectant properties against bacteria, fungi, and viruses [22], while vanillin finds applications in the pharmaceutical industry [23]. (Z)-cinnamyl benzoate serves purposes in perfumes, cosmetics, and exhibits antimycotic activity [24]. Rutamarin, apart from potential benefits against heart disease and diabetes, demonstrates antimicrobial and antifungal properties, suggesting its potential for treating infections. Moreover, rutamarin has been investigated for its cognitive function enhancement and anxiety reduction properties [25]. The study further unveils the antibacterial activity of cinnamon oil against *Aeromonas caviae*, as indicated by the zone of inhibition in Figure 2. The zone of inhibition, reflecting the area where bacterial growth is hindered, reveals a concentration-dependent antibacterial effect. Notably, as the concentration of cinnamon oil increased, so did the extent of the zone of inhibition. The results point towards the effectiveness of cinnamon oil as an antibacterial agent. As per the findings, Cinnamon essential oil displayed notable antimicrobial activity against *Aeromonas caviae*, surpassing the effectiveness of Ciprofloxacin.

The diverse concentrations of geranium essential oil extract (5, 10, 15, 20, and 25 μ l) demonstrated significant inhibitory effects on pathogenic strains, particularly *Aeromonas caviae*. The measured inhibition zones were 6.3 ± 0.11 , 8.4 ± 0.22 , 12.55 ± 0.50 , 17.56 ± 0.50 , and 40.22 ± 0.44 , respectively, indicating the area where bacterial growth was restricted around the oil on the culture plate. This implies that Cinnamon essential oil exerted an inhibitory influence on the growth of *Aeromonas caviae*, preventing its spread within the specified zone. In comparison, the standard antibiotic ciprofloxacin at 30 μ g/ μ l resulted in a zone of inhibition of 15 mm. However, the control antibiotic Ciprofloxacin exhibited a higher efficacy against *Aeromonas caviae*. This suggests that, under the given experimental conditions, Cinnamon essential oil demonstrated greater potency in inhibiting the growth of *Aeromonas caviae* compared to Ciprofloxacin. This indicates that higher concentrations of cinnamon oil demonstrate more robust antibacterial activity against *Aeromonas caviae* compared to ciprofloxacin at the tested concentration. The molecular mechanism responsible for the antibacterial activity of cinnamon oil is likely linked to its bioactive components, with cinnamaldehyde being a key player. Cinnamaldehyde possesses antimicrobial properties and is recognized for disrupting the integrity of bacterial cell membranes. Its ability to penetrate bacterial cell membranes causes structural damage, leading to the leakage of cellular contents. This disruption ultimately hinders bacterial growth and survival. Moreover, cinnamon oil may interfere with bacterial enzymes and metabolic processes, further contributing to its antibacterial effects. It's crucial to acknowledge that the precise molecular mechanism of cinnamon oil's



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antibacterial activity against *Aeromonas caviae* may involve multiple factors and could potentially be more intricate than the general mechanisms outlined here.

CONCLUSION

In summary, the chemical analysis of cinnamon oil revealed the presence of various compound classes, with phenol, vanillin, (Z)-cinnamyl benzoate, and rutamarin identified as the major constituents. These compounds exhibit diverse applications, ranging from disinfectants and pharmaceuticals to perfumes and protective agents against diseases. The antibacterial effectiveness of cinnamon oil against *Aeromonas caviae* displayed a concentration-dependent pattern, with higher concentrations yielding stronger inhibition. Notably, cinnamon oil demonstrated superior antibacterial activity compared to the standard antibiotic ciprofloxacin at the tested concentration. The mechanism of action involves the disruption of bacterial cell membranes by cinnamaldehyde, causing membrane damage and inhibiting growth. Additionally, interference with bacterial enzymes and metabolic processes may contribute to its antibacterial effects. However, a comprehensive understanding of the intricate molecular mechanisms requires further research. The study's findings endorse the potential use of cinnamon oil as a natural antimicrobial agent, emphasizing its promising applications in pharmaceutical and therapeutic realms.

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Declarations

Ethics approval Not applicable.

Consent to Participate Yes. All authors agreed to participate in this research.

Consent for publication Yes. All authors have approved the last version of the manuscript for its submission.

Author Contribution D.N.: Conducted GC-MS analysis and formal analysis. M.S.: Performed computational analysis and visualization. S.P.: Collected and processed plant material and assessed antimicrobial activity. B.G.: Contributed to experimental design, provided guidance, and executed the experiment. B.C.: Took responsibility for writing the original draft, as well as reviewing and editing.

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Conflict of interests The authors declare that they have no conflict of interests.

Availability of data and materials All the data generated or analyzed during this study are included in this article.

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Table 1: Qualitative phytochemical analysis of essential oils

Phytochemicals	Cinnamon oil
Acids	+
Alkaloids	+
Anthocyanins and Betacyanins	-
Carbohydrates	-
Cardiac Glycosides	+
Coumarins	+
Flavonoids	+
Glycosides	-
Phenols	+
Proteins	+
Quinones	-
Saponins	+
Starch	-
Steroids	+
Tannins	+
Terpenoids	+
Triterpenoids	+

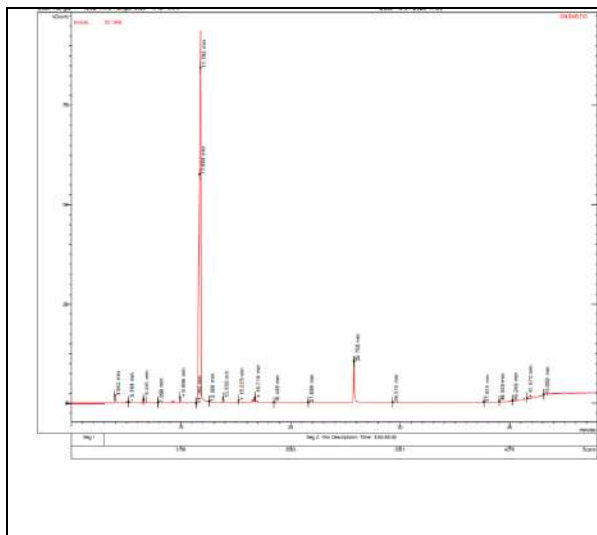


Figure 1: GC-MS chromatogram of Cinnamon oil

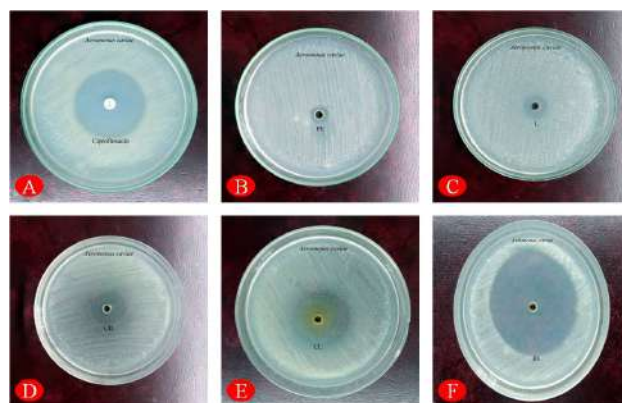


Fig. 2: Antibacterial activity of cinnamon oil against *Aeromonas caviae* A- Standard Ciproflaxin 300 mcg, B- 5 µg/µl of cinnamon oil, C- 10 µg/µl of cinnamon oil, D- 15 µg/µl of cinnamon oil, E- 20 µg/µl of cinnamon oil and F- 25 µg/µl of cinnamon oil.





Multiplicative Graph

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ABSTRACT

Let I_s be an S -prime ideal of a commutative ring R with unity of order p^t and $p^t q$, $t \geq 1$ respectively and A_s be the multiplicatively closed subset of R which is disjoint from the S -prime ideal I_s . In this paper a new graph called multiplicative graph is introduced and denoted by $G_{A_s}(R)$. The vertices of $G_{A_s}(R)$ are the elements of all A_s and any two vertices are adjacent if and only if their product is in any A_s of R . Furthermore, some graph theoretic and algebraic properties of a graph are investigated. Also, relationship between A_s and $nil(R)$ is discussed, where $nil(R)$ is the nilradical of R and proved that the total number of vertices of a graph is the number of elements in the complement of the set $nil(R)$. Finally using Euler's totient function, first Zagreb index and Randić index of $G_{A_s}(R)$ are generalized.

Keywords: S -prime ideal, Multiplicatively closed subset, Nilpotent elements, Orthogonal elements, Girth, Rank.

2010 AMS Subject Classification 05C25, 13A99, 16U99.

INTRODUCTION

Algebraic graph theory is the application of graph theory using algebraic conditions. Group theory, graph invariants and linear algebra are the three main areas of algebraic graph theory. In 1964, Bosak [5] introduced the graphs of semigroups. Later on, many authors developed the wide range of graphs from groups, they are [1, 17, 20], etc., In 2022, Kiruthika and Kalamani [14] derived a new graph from group theory called the vertex order graph and studied its complements with the edge condition. Also, they [15] partitioned the set of vertices and edges of the power graph of a group \mathbb{Z}_{pq} , p, q are primes. In 1988, Beck [4] introduced a graph from a commutative ring with unity. Several different graphs are defined by many authors: [7, 6], nilpotent graph by [8], graphs defined by orthogonality by [3],





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etc., In 2021, D. Kalamani and G. Ramya [12] introduced a graph called the product maximal graph, it is defined as their vertices are from the elements of a ring R and the vertices a, b are adjacent if their product is in the maximal ideal of R . In 2019, Ahmed Hamed and Achraf Malek [2] defined an S -prime ideal it represents the prime ideal's generalization of a ring R . It is defined as an ideal is S -prime if \exists an $s \in S$ such that $\forall a, b \in R$ if $ab \in I$, then $sa \in I$ or $sb \in I$, where S is the multiplicative subset of R which is disjoint from the ideal I . In 2023, D. Kalamani and Mythily. C. V [11] defined a graph denoted by $G_{S_d}(R)$ it is an undirected graph from the definition of S -prime ideal of R . The vertices are from a ring R and two vertices are connected if either sa or $sb \in I$ whenever the product $ab \in I$, I is an ideal of R and S is the multiplicative subset of R and $S \cap I = \emptyset$. Also, they discussed S -prime ideal of a local and non-local rings in [16]. A number linked to chemical composition that suggests a relationship between chemical structure and different physical attributes, chemical reactivity is called a topological graph index. Many degree based topological indices are discussed earlier [13, 21], in this paper first Zagreb index $F_1[G_{A_s}(R)] = \sum_{u \in V[G_{A_s}(R)]} [d(u)]^2$ and the Randić index of a multiplicative graph is presented. The product maximal graph and the S -prime ideal graph of a ring R were motivated to discover a graph $G_{A_s}(R)$ of finite order. In this paper the ring R is considered as a commutative ring with identity of order $n = p^t$ and $p^t q$, $t \geq 1$ respectively. The set A_s is the multiplicatively closed subset of R which is disjoint from the S -prime ideal I_s and introduced the new graph of R called multiplicative graph denoted by $G_{A_s}(R)$ whose vertex set V contains the elements of all the multiplicatively closed subsets A_s of R .

In section 2, some basic definitions are studied for algebraic and graph theoretical results from [9] and [19]. The notations and symbols of algebra and graph theory are studied from [9], [19] and Algebraic Graph Theory by C. Godsil and G. Royle [10]. In section 3, some examples of a multiplicative graph $G_{A_s}(R)$ of R , also relation between A_s and $nil(R)$ is discussed. In section 4 maximum, minimum distance, girth of the multiplicative graph $G_{A_s}(R)$ and also number of vertices in a graph $G_{A_s}(R)$ are derived. In section 5, degree of the vertex of $G_{A_s}(R)$ is generalized and using Welsh-Powell algorithm to generalize the chromatic number of the graph. In 1967, Welsh and Powell [18] introduced an upper bound for the chromatic number of a graph and its application to timetabling problem, it gives Welsh-Powell algorithm applied to find the chromatic number of a graph by using degree of the vertex. The following steps derive the Welsh-Powell graph coloring algorithm:

- First find the degree of the vertex $\deg(v)$ of every vertex in a graph.
- List the degree of the vertices in descending sequence.
- Next color the first vertex in the list.
- Move to the next vertex in the list and color the vertices which are not connected to the colored vertex then color it with same color.
- Repeat in this way to color all the uncolor vertices in a graph. In section 6, rank and nullity of the multiplicative graph are generalized by using the adjacency matrix of the multiplicative graph $G_{A_s}(R)$ and in section 7, by using Euler's totient function, the first Zagreb index and Randić index of the multiplicative graph is generalized.

PRELIMINARIES

The basic definitions of a commutative ring, zero-divisor, unit, prime ideal, maximal ideals, orthogonal, diameter, girth and complete graph are given in this section.

Definition 2.1. Let a be an element in R ; it is called a **zero-divisor** if \exists a nonzero element $b \in R$ such that either $a \cdot b = 0$ or $b \cdot a = 0$.

Definition 2.2. An element u from a ring is called a **unit** if $\exists v \in R$ $\exists uv = vu = 1$.

Definition 2.3. A proper ideal P is called a **prime ideal** if $a \cdot b \in P$ where $a, b \in R$ then either a or $b \in P$.

Definition 2.4. The subset M is called a **maximal ideal** of R if $M \neq R$ and for any I of R is in M and there is no proper ideal that contains M .





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Definition 2.5. Let $S \subseteq R$ be the **multiplicatively closed set** such that the following two conditions hold:

- $1 \in S$,
- $ab \in S \forall a, b \in S$

The identity element $0 \in R$ is not in the set S .

Definition 2.6. Let $a \in R$ is called **nilpotent** if $\exists t \in \mathbb{Z}^+ \ni a^t = 0$. The collection of all nilpotent elements, denoted by $nil(R)$.

Definition 2.7. The elements $a, b \in R$ are said to be **orthogonal** ($a \perp b$) if $ab = 0$.

Definition 2.8. Let $I \subset R$ disjoint with $S \subseteq R$. The ideal I is called S -prime if $\exists a, b \in R$ with $ab \in I$ then $sa \in I$ or $sb \in I$.

Definition 2.9. The smallest number of edges in any cycle within the graph is the **girth** of a graph. If the graph has no cycles, the girth is considered to be infinite.

Definition 2.10. Maximum length of the shortest paths connecting any two vertices is the **diameter** of a graph and it is denoted by $diam(G)$. Smallest value of the greatest distance between any vertex and all other vertices in the graph is the **radius** of a graph, it is denoted by $rad(G)$. The diameter and radius of a trivial graph is zero.

Definition 2.11. In a simple graph G , every vertex adjacent to another vertex is called complete.

Definition 2.12. The smallest number of colors required to label the vertices of a graph is called **chromatic number** it is denoted by $\chi(G)$. In order to give distinct colors to vertices that are adjacent.

Definition 2.13. A **clique** of a graph is the size of the maximal complete subgraph of the graph which is denoted as $\omega(G)$.

Definition 2.14. The **rank** of G denoted by $\rho(G)$ is the count of λ , where λ is the non-zero eigen values of the $adjM$ of G where $adjM$ is the adjacency matrix M . The **nullity** of G is defined as the count of the λ 's which are zero of the $adjM$ of G and it is denoted by $\eta(G)$. The dimension of a matrix M is $diamM = \rho(M) + \eta(M)$.

Definition 2.15. **Randi 'c index** of graph G is given by, $\mathcal{R}(G) = \sum_{uv \in e(G)} \frac{1}{\sqrt{d(u)d(v)}}$, $u, v \in v(G)$ and $uv \in e(G)$, where $v(G)$ and $e(G)$ are the vertex and edge set of G .

MULTIPLICATIVE GRAPH OF A RING

In this section, a graph from ring is introduced and discusses the relation between the multiplicative set A_s which contains disjoint elements of I_s and $nil(R)$ of a ring of order n , where $nil(R)$ is nilradical of R , includes every nilpotent element of R .

Definition 3.1. Let R be a finite commutative ring and I_s be an S -prime ideal of R . Let A_s be the multiplicatively closed subset of R which is disjoint from the S -prime ideal I_s of R . The multiplicative graph of R denoted by $G_{A_s}(R)$ is a graph whose vertices are the collection of all the elements of the multiplicatively closed subsets A_s of R and two vertices are only connected if and only if their product is in any multiplicatively closed subsets A_s of R .

Example 3.1. Let $R = \mathbb{Z}_9$ be the local ring the only S -prime ideal I_s is the prime ideal $I_1 = \{0, 3, 6\}$. Let $A_s = R - I_s$ is complement of I_s . The set A_s is disjoint from I_s . Vertex set $V(G_{A_s}(\mathbb{Z}_9))$ is $A_1 = \{1, 2, 4, 5, 7, 8\}$ and the multiplicative graph of \mathbb{Z}_9 shown in Figure 1.

Example 3.2. Let $R = \mathbb{Z}_{14}$ be the semilocal ring and their S -prime ideals are





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$$I_1 = \{0, 2, 4, 6, 8, 10, 12\}$$

$$I_2 = \{0, 7\} \text{ and}$$

$$I_3 = \{0\}.$$

Disjoint multiplicative subsets of S -prime ideals are

$$A_1 = \{1, 3, 5, 7, 9, 11, 13\}$$

$$A_2 = \{1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13\} \text{ and}$$

$$A_3 = \{1, 2, 4, 8\}$$

The vertices V of a graph $G_{A_s}(\mathbb{Z}_{14})$ are the elements of all the collections of A_1, A_2 and A_3 of $R = \mathbb{Z}_{14}$. i.e., $V = \cup_s A_s$.

Therefore, the vertex set $V = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13\}$. The Figure 2 shows that an orthogonal element in a graph is non-adjacent. For instance, the orthogonal elements of 7 in \mathbb{Z}_{14} are 2, 4, 6, 8, 10 and 12. The vertex 7 is not adjacent to the elements of $\{2, 4, 6, 8, 10, 12\}$. The vertices from I_1 is not adjacent to the vertices of any other I_s . By the above examples, it is noted that the multiplicative graph $G_{A_s}(R)$ is complete if R is local ring. The set A_s are multiplicatively closed so that every element of a set A_s is adjacent to the multiplicative identity 1 of R . All the element of a set A_s is V of a graph $G_{A_s}(R)$ they are adjacent with each other and no vertex can be adjacent with itself. Thus, the multiplicative graph of a finite ring R with unity it is a simple and connected.

Proposition 3.1. Let R be a ring of order n . The vertex set V of a multiplicative graph $G_{A_s}(R)$ does not have any nilpotent elements of a ring R .

Proof. Let A_s be the multiplicatively closed subset of R which is disjoint from the S -prime ideal I_s of R and the vertex set of a multiplicative graph of R contains all the elements of A_s . Assume that if the nilpotent element 0 in the vertex set V then 0 is in A_s of R . It contradicts to the definition of multiplicatively closed subset and the S -prime ideal property that $I_s \cap A_s = \emptyset$. Therefore $0 \notin A_s$. The set $nil(R)$ is contained in the intersection of the prime ideals P_i and every prime ideal P_i is the S -prime ideal I_s of R where $1 \leq i < n$. Therefore, the multiplicatively closed subset A_s is also disjoint from $\cap P_i$. Thus, the vertex set V of $G_{A_s}(R)$ does not have any nilpotent elements of a ring R .

MAXIMUM AND MINIMUM DISTANCE OF A GRAPH

A multiplicative graph of a ring R whose vertex set is the collection of all A_s of R which is disjoint from the S -prime ideal I_s and draw a graph for a vertex set V is a multiplicative graph $G_{A_s}(R)$ is connected. The most important thing for drawing a graph is its vertices. The cardinality of vertices of a multiplicative graph and maximum distance of the graph $G_{A_s}(R)$ is $diam[G_{A_s}(R)] = \{0, 1, 2\}$ are generalized in this section.

Theorem 4.1. Let $G_{A_s}(R)$ be a graph of a ring R of order n and V be the vertex set of a multiplicative graph $G_{A_s}(R)$. Then the total number of vertices in a graph is $|V| = |nil(R)|$.

Proof. Let A_s be the multiplicatively closed subset of R which is disjoint from the S -prime ideal I_s . By Proposition 3. 1. the vertex set V does not contain any nilpotent element of R . If x is any non-nilpotent element of a ring then $x^t \neq 0$ for all $t \in \mathbb{Z}^+$. Assume that x is not an element of the set A_s of R then $x^t \notin A_s$ which means $x^t \in I_s$ for all $t \in \mathbb{Z}^+$. Then $x^t = 0$ for some $t \in \mathbb{Z}^+$. This implies that x is nilpotent. It contradicts to x is non-nilpotent. Therefore, the vertex set V contains all the set A_s of R and the set A_s does not contains any nilpotent element. Since all the nilpotent elements of R contained in $nil(R)$. i.e., $V = |nil(R)|$. Then the total number of vertices, $|V| = |nil(R)|$.

Corollary 4.2. If R is a field, then $|V| = n - 1$.

Proof. In a field, every non-zero elements are the units of R and it is a local ring so they have unique S -prime ideal I_s . The disjoint multiplicatively closed subset of I_s is A_s . It contains all the units of R . That is A_s contains $R - \{0\}$. Therefore $|V| = n - 1$.

Theorem 4.3. Let R be a ring of order $n > 2$. Then $diam(G_{A_s}(R))$ is





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$$diam(G_{A_s}(R)) = \begin{cases} 1 & \text{if } R \text{ is local} \\ 2 & \text{otherwise.} \end{cases}$$

Proof. Case (i)

Let R be a local ring. The multiplicative graph $G_{A_s}(R)$ is complete such that all vertices are connected to every other vertex in $G_{A_s}(R)$. $\therefore diam(G_{A_s}(R)) = 1$.

Case (ii)

Let R be a non-local ring and a, b are the vertices of a multiplicative graph of R . Let us consider a, b are units of R and $a, b \notin I_s$ since $a, b \in A_s$ such that their product $ab \in A_s$ then they are adjacent in $G_{A_s}(R)$ $\therefore d(a, b) = 1$. Let a, b are non-units of R and $a, b \in A_s$ which are in the S -prime ideal I_s . If a, b are in same I_s then they are adjacent in $G_{A_s}(R)$. $\therefore d(a, b) = 1$. If a, b are in different multiplicatively closed subset A_s then a, b in different S -prime ideal I_s of R and their product does not exist in the vertex set of $G_{A_s}(R)$. $\therefore d(a, b) = 2$ Since every vertex of $G_{A_s}(R)$ adjacent to 1 then the distance of a vertices

$$d(a, b) = \begin{cases} 1 & \text{if } a, b \text{ are units} \\ 2 & \text{otherwise.} \end{cases}$$

The maximum distance is the diameter of the multiplicative graph of R . Therefore $diam(G_{A_s}(R)) = 2$.

Corollary 4.4. A ring of order $n = 2$ then $diam(G_{A_s}(R)) = 0$.

Corollary 4.5. Let R be a ring of order n . Then the radius of a multiplicative graph is

$$rad(G_{A_s}(R)) = \begin{cases} 0 & \text{if } n = 2 \\ 1 & \text{otherwise.} \end{cases}$$

A graph $G_{A_s}(R)$ is connected and the order of a ring $n = \{3, 4\}$ are K_2 complete and they are isomorphic. The following theorem states the girth of the multiplicative graph of a ring R .

Theorem 4.6. Let R be a ring. Then the girth of a multiplicative graph is

$$gr(G_{A_s}(R)) = \begin{cases} 3 & \text{if } n > 4 \\ \infty & \text{otherwise.} \end{cases}$$

Proof. Case (i) $n > 4$

Let a and b are the elements in the same multiplicative subset A_s . Then a and b are adjacent in $G_{A_s}(R)$ which are adjacent to the units of R in $G_{A_s}(R)$. Therefore, $1 - a - b - 1$ form a cycle. Thus, $gr(G_{A_s}(R)) = 3$.

Case (ii)

The multiplicative graph $G_{A_s}(R)$ is a singleton graph if the ring of order is 2. Therefore, the multiplicative graph has no cycle. Thus, $gr(G_{A_s}(R)) = \infty$.

DEGREE OF THE VERTEX AND CHROMATIC NUMBER OF A GRAPH

Let vertex set of $G_{A_s}(R)$ are collection of all A_s of a ring R and number of vertices $|V| = |A_s|$ and the elements of R are units and zero-divisors. Consider zero-divisors of R are non-units of R in the subsequent theorem, here talk about the degree of the vertices in the multiplicative graph $G_{A_s}(R)$.

Theorem 5.1. Let $G_{A_s}(R)$ be the multiplicative graph of a ring R then,

$$deg(v) = \begin{cases} m - 1 & \text{if } v \text{ is a unit} \\ |A_s| - 1 & \text{otherwise.} \end{cases}$$

Proof. Let A_s be the subset of R and V be the vertex set contains all the elements of the subsets A_s of a ring R .





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Case (i)

Let $v \in V$ be the unit element of a ring R . It is contained in the subsets A_s of R . The vertex v is connected to every other vertex of the multiplicative graph $G_{A_s}(R)$ and there is no vertex adjacent to itself. It is a simple graph. Therefore, the degree of the vertex of a multiplicative graph $G_{A_s}(R)$ is, $\deg(v) = m - 1$ where $m = |V|$.

Case (ii)

Let $v \in V$ be the non-unit element of a ring R . If $v \in A_s$ then v is adjacent to all the elements of A_s and non-adjacent to non-unit element of other multiplicatively closed subset A_s of R , therefore $\deg(v) = |A_s| - 1, v \in A_s$ where $|A_s|$ is the number of elements in A_s .

Thus, $\deg(v) = \begin{cases} m - 1 & \text{if } v \text{ is a unit} \\ |A_s| - 1 & \text{otherwise.} \end{cases}$

Using the Welsh-Powell algorithm [18] to find $\chi(G_{A_s}(R))$ for the multiplicative graph $G_{A_s}(R)$ in the next theorem.

Theorem 5.2. Let A_s be the multiplicatively closed subset of R with unity of order n and V be the vertex set is the collection of all A_s . Then the chromatic number of the multiplicative graph $G_{A_s}(R)$ is $\chi(G_{A_s}(R)) = \text{Max}\{|A_s|\}$.

Proof. Let vertex set of $G_{A_s}(R)$ is $V = \{u_1, u_2, u_3, \dots, u_k, v_1, v_2, v_3, \dots, v_l\}$ where vertices u_k and v_l are units and non-units of a ring R and $k + l = m$. By Theorem 5.1, $\deg(v)$ of the multiplicative graph $G_{A_s}(R)$ are calculated. After finding the degree of the vertex they are arranged in descending order. First color the vertex u_1, u_1 is connected to all the vertices of $G_{A_s}(R)$ and move to the second unit u_2 by different color. The process can be repeated till all the units are colored with k colors namely C_1, C_2, \dots, C_k respectively. Next move on to the non-unit of maximum degree v_j with the color C_{k+1} . The sets A_1 and A_2 are the multiplicative subsets of R . Let v_1, v_2, \dots, v_τ be the non-units of A_1 . The non-unit v_i of A_1 is adjacent to all the other non-units of A_1 and is not adjacent to the non-units of A_2 , where $i = 1, 2, 3, \dots, \tau$. Suppose v_1 has the maximum degree then it is colored with the color C_{k+1} . Choose the next non-unit of maximum degree in A_1 and it can be colored with the color C_{k+2} . Continuing the same process till all the vertices A_1 are colored and hence the set A_1 has $C_{k+\tau}$ colors. If A_2 has ρ non-units and $\rho \leq \tau$ then there are $C_{k+\tau}$ colors for the multiplicative graph $G_{A_s}(R)$. If $\rho > \tau$ then there are $C_{k+\rho}$ colors for the multiplicative graph $G_{A_s}(R)$. The minimum number of different colors is the maximum cardinality of $A_i, i = 1, 2$. Therefore, the minimum number of colors used for the graph $G_{A_s}(R)$ is the maximum cardinality of $A_i, i = 1, 2$. Then the chromatic number of the graph is, $\chi(G_{A_s}(R)) = \text{Max}\{|A_s|\}$.

The $\chi(G_{A_s}(R))$ also same as the maximum degree of the vertex in a graph.

Example 5.1. Let us consider a ring \mathbb{Z}_{10} and the S -prime ideal of \mathbb{Z}_{10} are

$I_1 = \langle 2 \rangle = \{0, 2, 4, 6, 8\}$

$I_2 = \langle 5 \rangle = \{0, 5\}$ and

$I_3 = \langle 10 \rangle = \{0\}$

Disjoint multiplicative subsets of S -prime ideals are

$A_1 = \{1, 3, 5, 7, 9\}$

$A_2 = \{1, 2, 3, 4, 6, 7, 8, 9\}$ and

$A_3 = \{1, 5\}$

Vertex set of $G_{A_s}(\mathbb{Z}_{10})$ is collection of all A_s of a ring $R = \mathbb{Z}_{10}$.

Therefore, $V = \cup_s A_s = \{1, 2, 3, 4, 5, 6, 7, 8, 9\}$.

By using Theorem 5.1. finding degree of the vertices in $G_{A_s}(\mathbb{Z}_{10})$ and according to the first step of the Welsh-Powell algorithm, sort the vertices by their degrees as shown in Table 1. The next step is to color the vertex which degree is highest. In the Figure 3 vertices $\{1, 3, 7, 9\}$ are units of \mathbb{Z}_{10} adjacent to each other so they need different color. It is shown in Figure 3. The vertex set $\{2, 4, 6, 8\}$ are adjacent to each other and adjacent to all units of \mathbb{Z}_{10} such that they also need different color those colors are different from the already colored vertices. In Figure 3, vertex $\{5\}$ is adjacent to all the units of \mathbb{Z}_{10} and not adjacent with the vertex set $\{2, 4, 6, 8\}$. So, one of the colors of vertices $\{2, 4, 6, 8\}$ is the





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color of the vertex {5}. It is easiest way to find minimum color of a graph. The $\chi(G_{A_s}(R))$ is the maximum complete of the graph with m vertices. In Figure 3 the vertex set from A_2 is form a maximum complete. Thus $\chi(G_{A_s}(\mathbb{Z}_{10})) = |A_2| = 8$.

Corollary 5.3. Let R be a ring. Then the clique number of a multiplicative graph is $\omega(G_{A_s}(R)) = \chi(G_{A_s}(R))$.

RANK OF A MULTIPLICATIVE GRAPH

In this section rank and nullity of the multiplicative graph $G_{A_s}(R)$ of a ring R are generalized.

Theorem 6.1. Let $R = \mathbb{Z}_n, n > 2$ be a ring and V be the vertex set of $G_{A_s}(R)$. Then $rank(G_{A_s}(R)) = |V|$.

Proof. The vertex set V is the collection of elements of A_s of R . It contains all units of R and the units of R are adjacent with all other vertices in $G_{A_s}(R)$. No vertex in $G_{A_s}(R)$ is adjacent with itself. By Theorem 5.1, if vis a unit then $deg(v) = m - 1$, where $m = |V|$ of a multiplicative graph $G_{A_s}(R)$. If the vertex vis a non-unit and $v \in A_s$ for some s , then $deg(v) = |A_s| - 1$. Let $M(G)$ be the adjacency matrix of $G_{A_s}(R)$ it is a simple graph do not have an identical row (columns). Hence $|M(G)| \neq 0$. The matrix $M(G)$ of a graph $G_{A_s}(R)$ of the form

$$\begin{bmatrix} 0 & 1 & 1 & 1 & \dots & 1 & 1 \\ 1 & 0 & \dots & \dots & \dots & \dots & \dots \\ 1 & \dots & 0 & \dots & \dots & \dots & \dots \\ 1 & \dots & 0 & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ 1 & 0 & \dots & \dots & \dots & \dots & 0 \end{bmatrix}$$

It is a non-singular matrix and hence it has no zero eigenvalues. Thus $rank(G_{A_s}(R)) = |V|$.

The rank of a multiplicative graph $G_{A_s}(R)$ also calculate by the Theorem 4.1. as $rank(G_{A_s}(R)) = \overline{nil(R)}$.

Corollary 6.2. Let $G_{A_s}(R)$ be the multiplicative graph of a ring R . Then the nullity of the graph is $\eta(G_{A_s}(R)) = 0$.

RANDIĆ INDEX OF A MULTIPLICATIVE GRAPH

Euler’s totient function, denoted as $\phi(n)$ it calculates the number of integers between 1 and n that share no common factors with n other than 1. By using Euler’s totient function the first Zagreb index F_1 of a multiplicative graph are generalized in the subsequent theorem. Let R be the ring of order either p or $p^t q, t \geq 1$. The ring of order $p^t q$ has two prime ideals generated by p and q and their complement sets are A_1 and A_2 respectively. The Euler’s totient function, denoted as $\phi(n)$ gives the number of units of $R = \mathbb{Z}_n$. With the help of totient function, the first Zagreb index F_1 and Randić indices of a multiplicative graph are generalized and are shown in the following theorems. Denote the cardinality of A_i as η_i and the difference between η_i and $\phi(n)$ as ζ_i for $i = 1, 2$.

Theorem 7.1. Let $G_{A_s}(R)$ be a connected graph of order $n \neq p$ with m vertices. Then the first Zagreb index of $G_{A_s}(R)$ is $F_1[G_{A_s}(R)] = \phi(n)(m - 1)^2 + \sum \zeta_i(\eta_i - 1)^2$.

Proof. By Theorem 5.1, obtained degree of the vertices is $m - 1$ if vertices are units of R and otherwise degree of vertex is $m - 1$. Thus, the two different vertex degrees are obtained for the multiplicative graph. Therefore, the first Zagreb index of the multiplicative graph is

$$\begin{aligned} F_1[G_{A_s}(R)] &= \sum_{u \in V[G_{A_s}(R)]} deg(u)^2 \\ &= \sum_{u \in U(R)} deg(u)^2 + \sum_{u \notin U(R)} deg(u)^2 \end{aligned}$$





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$$\begin{aligned}
 &= \sum_{u \in U(R)} \text{deg}(u)^2 + \sum_{u \in A_1} \text{deg}(u)^2 + \sum_{u \in A_2} \text{deg}(u)^2 \\
 &= \phi(n)(m-1)^2 + \zeta_1(\eta_1-1)^2 + \zeta_2(\eta_2-1)^2 \\
 F_1[G_{A_s}(R)] &= \phi(n)(m-1)^2 + \zeta_i(\eta_i-1)^2.
 \end{aligned}$$

Example 7.1. Let $G_{A_s}(R)$ of order 13. Then the first Zagreb index of $G_{A_s}(\mathbb{Z}_{14})$ is,
 $F_1[G_{A_s}(\mathbb{Z}_{14})] = \phi(n)(m-1)^2 + \zeta_i(\eta_i-1)^2$. Thus $F_1[G_{A_s}(\mathbb{Z}_{14})] = 1626$.

Corollary 7.2. First Zagreb index of a multiplicative graph of a prime order is $F_1[G_{A_s}(R)] = m(m-1)^2$.

Theorem 7.3. Let $G_{A_s}(R)$ be a multiplicative graph of order m . Then the Randić index of a multiplicative graph is $\mathcal{R}[G_{A_s}(R)] = \frac{\phi(n)c_2}{(m-1)} + \frac{\zeta_i\phi(n)}{\sqrt{(m-1)(\eta_i-1)}} + \frac{\zeta_i c_2}{(\eta_i-1)}$, $i = 1, 2$.

Proof. Let $uv \in E[G_{A_s}(R)]$ be the edge set of a multiplicative graph $G_{A_s}(R)$. Then the Randić index of a multiplicative graph is

$$\begin{aligned}
 \mathcal{R}[G_{A_s}(R)] &= \sum_{uv \in E(G_{A_s}(R))} \frac{1}{\sqrt{\text{deg}(u)\text{deg}(v)}} \\
 &= \sum_{u,v \in U(R)} \frac{1}{\sqrt{d(u)d(v)}} + \sum_{u \in U(R), v \notin U(R)} \frac{1}{\sqrt{\text{deg}(u)\text{deg}(v)}} + \sum_{u,v \notin U(R)} \frac{1}{\sqrt{\text{deg}(u)\text{deg}(v)}} \\
 \mathcal{R}[G_{A_s}(R)] &= \frac{\phi(n)c_2}{(m-1)} + \frac{\zeta_i\phi(n)}{\sqrt{(m-1)(\eta_i-1)}} + \frac{\zeta_i c_2}{(\eta_i-1)}.
 \end{aligned}$$

Example 7.2. Let $G_{A_s}(\mathbb{Z}_{10})$ of order 9. Then the Randić index of a multiplicative graph $G_{A_s}(\mathbb{Z}_{10})$ is,

$$\begin{aligned}
 \mathcal{R}[G_{A_s}(\mathbb{Z}_{10})] &= \sum_{uv \in E(G_{A_s}(\mathbb{Z}_{10}))} \frac{1}{\sqrt{\text{deg}(u)\text{deg}(v)}} \\
 &= 16 \frac{1}{\sqrt{56}} + 6 \frac{1}{\sqrt{64}} + 4 \frac{1}{\sqrt{32}} + 6 \frac{1}{\sqrt{49}} \\
 \mathcal{R}[G_{A_s}(\mathbb{Z}_{10})] &= 4.4523.
 \end{aligned}$$

Corollary 7.4. The Randić index of a multiplicative graph with m vertices of a ring of prime order is $\frac{m}{2}$.

CONCLUSIONS

In this paper, a new graph called the multiplicative graph $G_{A_s}(R)$ is introduced. Some basic graph theoretic properties namely number of vertices, degree of a vertex, girth, diameter, maximum and minimum distance of a graph, chromatic number and clique number are generalized and also algebraic properties rank and nullity are interpreted for the multiplicative graph of a finite commutative ring R with unity. Finally, first Zagreb index and Randić index of $G_{A_s}(R)$ are generalized.

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Table 1: Degree of the vertices in a multiplicative graph $G_{A_5}(\mathbb{Z}_{10})$

Vertex	1	3	7	9	2	4	6	8	5
Degree	8	8	8	8	7	7	7	7	4





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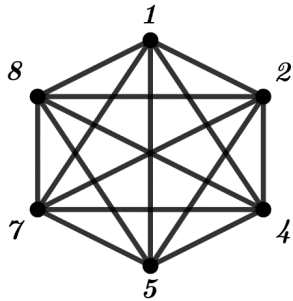


Figure 1: A Multiplicative Graph $G_{A_9}(\mathbb{Z}_9)$

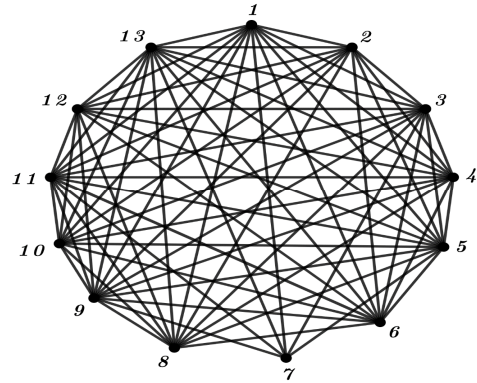


Figure 2: A Multiplicative Graph $G_{A_8}(\mathbb{Z}_{14})$

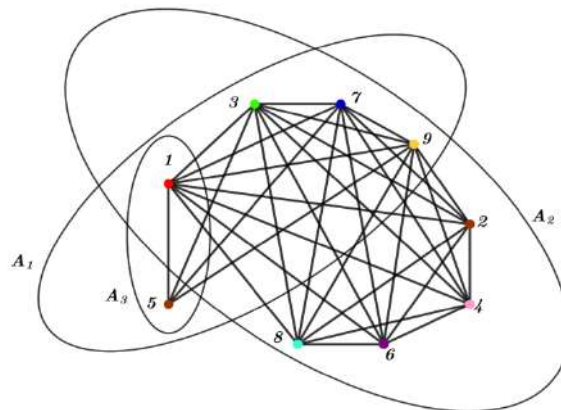


Figure 3: A Multiplicative Graph $G_{A_5}(\mathbb{Z}_{10})$





A Correlation of Rock Types with Physico-Chemical Properties of Soils Around Bar, Raipur Tehsil, Pali District, Rajasthan

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ABSTRACT

Minerals and nutrients in soil result by weathering, erosion and deposition the rock particles. These make soil fertile and productive. These are the most important ingredients of soils, which have an effect on organic activities. The present study is confined to South Delhi Fold Belt (SDFB), that's an aggregate of hilly and pene-plained place. A major part of western side covered with soil with scanty outcrops of Banded Gneisses Complex (BCG). In northwestern aspect of Bar, in the back of the Ramdev temple very big hillocks of granitic gneisses are present, while within side the southwestern aspect close to Haripur Railway station once more the outcrops of granitic gneisses are present, which are covered by coarse textured soils of variable depths. The parent rocks had definite impact on soil characteristics and nutrient. The present paper highlights impact of parent rocks on soil characteristics.

Keywords: Delhi Fold Belt, Banded Gneisses Complex (BCG), arid region, Aravalli, Bar, Agriculture



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INTRODUCTION

India has a long history of being an agrarian society, with a substantial portion of its population involved in agriculture. Soil is indeed a valuable and non-renewable resource. Its importance lies in providing a medium for plant growth and supporting various forms of vegetation essential for human sustenance and ecosystem balance. Soil depth, texture, and fertility are pivotal factors that influence the health and productivity of the soil. Farmers and land managers need to understand and manage these factors effectively for sustainable agriculture. The interaction between soil quality, climate, and agricultural practices significantly impacts crop productivity. Higher crop yields contribute to food security, economic prosperity, and overall societal well-being. The soils have originated through the processes of weathering and erosion acting on rocks. These soils may either form in situ or be transported through mechanisms like sand drift or aeolian processes. Regardless of their mode of formation, the soils retain the distinctive characteristics of the parent rock, evident in the minerals that compose the soil. Depending on the raw material, soils exhibit varying morphological, physical, chemical, and biological properties (Pandurang 2022). This study specifically explores the relationship between parent rocks and the soils formed in Bar, Raipur tehsil of Pali district.

MATERIALS AND METHODS

The soils have been studied at 11 sites at Phatakhera, Megarda, Bhilan, Kanuja and Kotra of Pali district, Rajasthan (Table 2). The rocks in the study area predominantly exhibit a conglomeratic nature, particularly in the Bar conglomerate horizon, and are characterized by folding and metamorphism. The soil samples representing various soil types were analyzed for both physicochemical and chemical properties. The chemical properties were determined utilizing a UV-VIS spectrophotometer (Model Shimadzu-1650PC). Additionally, the soil texture was assessed using the particulate organic matter (POM) method. To analyze the available nitrate nitrogen (NO₃-N), we utilized the extraction procedure outlined by Cataldo et al. (1975). Olsen's method (1954) was employed for the extraction and estimation of available phosphorous (PO₄-P). Titrimetric and DTPA methods were employed for assessing other soil nutrients. Lithostratigraphic classification and mineralographic data for the rock samples are provided in Tables 2.

RESULTS AND DISCUSSIONS

GEOLOGY OF THE AREA

The rocks in the southwestern part of the study area comprise scattered outcrops of granitic gneisses, mostly concealed beneath a thick layer of loose sand. Throughout the study area, posts-tectonic dikes, pegmatite and granite sills, and quartz veins are prevalent. Notably, there is widespread igneous intrusive activity, particularly of an acidic nature, in areas such as Bar, Phatakhera, Bhilan, Kotra, and their immediate vicinity. While faint impressions of granitization are observed in the form of veins and boudins at Phatakhera and Megarda villages, they are not as distinctly marked as rock formations. The presence of pegmatite, granite, and quartz veins signifies intrusive activity in the region, a phenomenon also documented by Naha et al. (1984). These veins contain minerals like tourmaline, garnet, beryl, etc. At the Kanuja-Sawanji ki Bariya road section, a distinct break in slope is observed between a hill and the next terrace level. Further southeast, there is a lower terrace level where the Sendra Formation is exposed. A few meters downstream from the Sukri river section at Bheru ki Bariya, well-exposed dark green amphibolite bands alternate with sillimanite gneiss. A detailed examination of the rock sequences of the Sendra Formation along the Sukri river section aimed to identify various lithological units. These include medium to coarse-grained gneisses, the crystalline content in migmatite, and the gradational contact of calc amphibolite gneiss with intrusive granite at Bheru ki Bariya, Kanuja, and Kotra villages, respectively (Figure 1& Table 1). The study area encompasses three primary tectonic divisions of the Delhi Supergroup, extending from southwest to northeast, namely the Banded Gneiss Complex (BGC, as described by Heron in 1953), Barotia (Alwar Group), and Sendra Formation (Ajabgarh



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Group). Each of these tectonic divisions exhibits distinct displacement patterns within the study area. The Banded Gneiss Complex (BGC) forms the Precambrian basement in the southwestern part and constitutes the lowermost tectonic unit in the region (Roy et al., 1985). An unconformity separates the BGC from the overlying rocks of the Barotia Formation (Gangopadhyay and Lahiri, 1983). The Barotia Formation comprises the Bar conglomerate horizon, calc amphibolite schist, quartzite schist, and calc-schist with intercalated quartzite schist. The Bar conglomerate horizon further divides into quartzofeldspathic schist, Bar conglomerate schist, garnetiferous mica schist, staurolite schist, and kyanite schist. Moving towards the northeastern part of the study area, the Sendra Formation overlays the region. Dolomite, equivalent to Nandana crystalline limestone according to Heron (1953), serves as a conformable separation between the Sendra Formation and the underlying Barotia Formation. The Sendra Formation is characterized by substantial gneisses with alternating bands of mica schist and foliated quartzite (Tripathi et al. (2015).

SOIL OF STUDY AREA

The soil in the Bar area is intricate, exhibiting high variability in composition, and reflects a diversity of parent materials and physiographic land features. Based on their characteristics, the soils are categorized into five significant groups: (1) light soils or sandy soils, (2) sandy loam or light-medium soils, (3) loam or medium soils, (4) heavy soils, including clay or loam to clay, and (5) shallow rocky or skeletal soils and hilly soils. These encompass grey-brown (wasteland soil), ferruginous pink soil, blended pink, black soil, medium black soil, and alluvial soils. The eastern side of the study area is characterized by rocky and hilly terrain, covered with shallow gravelly and superficial soils, primarily under forest or wastelands. Bernhard-Reversat (1982) noted a strong correlation between soil and vegetation in this area, which belongs to the Barotia and Sendra formations and the Kotra Intrusive granite of the Delhi Supergroup. Among the 11 sites surveyed, four (Phatakhera I, II, and Megarda I, II) cover the Barotia Formation, five (Bhilan I, II, Kanuja I, II) cover the Sendra Formation, and two (Kotra I, II) cover the Kotra Intrusive granite. Metamorphosed dolomite formations are situated on the eastern side of Phatakhera and Megarda villages. Phatakhera, located near Bar market, rests on Bar Conglomerate mica schist, presenting an eroded patch adjacent to the Bar conglomerate bed. Megarda features a small hillock of Calc amphibolite schist, concealed beneath a substantial layer of soil and rock formations. Bhilan and Kotra sample sites are situated on metamorphosed migmatite, with steeply sloping hills. Kotra, in particular, is located in the highly hilly terrain of Kotra Intrusive granite rocks. On the western side, the landscape is relatively plain, with variations in soil depth from shallow to very deep and in texture from sandy loam to sandy clay loam. The soils are brown, calcareous in the lower horizon, and highly productive under both rainfed and irrigated conditions. Gupta (1958) studied desert sands in Rajasthan, finding various easily weatherable minerals of aeolian origin, such as hornblende, feldspars, kyanite, and mica.

Dhir and Singh (1985) reported that in gray-brown soils, illite is the dominant clay mineral, followed by mica, smectite, vermiculite, kaolinite, attapulgite, and chlorite. In the Yamuna alluvial plain in Haryana, Shanwal et al. (1989) identified mica as the predominant clay mineral in soil, followed by kaolinite, chlorite, vermiculite, and smectite. They suggested that the presence of fibrous minerals is due to aeolian material from Rajasthan and not as an alluvial deposit of the Yamuna River. Kasser et al. (1979) studied the sands of red soils and observed quartz as the dominant mineral, with light pink feldspars occurring as an accessory mineral and significant amounts of opaque pyroboles and epidotes. Additionally, moderate amounts of zircon, rutile, tourmaline, and staurolite were noted. The high magnesium availability in soils is associated with the alteration products of ultramafic rocks. The potassium content in the soils shows no correlation with the geology of the area. Micronutrients such as iron and manganese exhibit a strong dependence on the bulk chemistry and mineralogy of the parent rock material. According to Moraetis et al. (2006), the bulk chemistry and mineralogy of the parent rock affect the availability of Mg^{2+} in the soils. Regions underlain by ultramafic parent rocks displayed an oversupply of Mg^{2+} in soil solution. In contrast, potassium availability did not show any correlation with the bulk chemical analysis and mineralogy of the soil; instead, it displayed a good correlation with the particle size distribution, especially with soil clay content. The input and output of magnesium and potassium were strongly related to the availability of these elements in vegetation. Furthermore, the deficiency of essential micronutrients such as manganese and iron followed the bulk chemical analysis and mineralogy of the soil, while zinc and copper showed no correlation with the chemistry and mineralogy



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of the different soil types. A direct relationship exists between nutrient concentrations present in soil stores and nutrient deficiency in the soil. Nutrient concentrations in plants are typically correlated with nutrient availability in the soil. Concentrations of nutrients are expected to be higher in under storey vegetation compared to open grassland vegetation. Garcia-Moya and McKell (1970) observed that shrubs help maintain the pool of soil nutrients in desert ecosystems by creating islands of organic matter accumulation. Tiedmann and Klemmedson (1973) studied soil profiles under the canopy zone of Mesquite trees (*Prosopis juliflora* (Swartz) DC.) and compared them with soil from adjacent openings at three depths near Tucson, Arizona. Bulk density was lower in the soil under Mesquite but increased with depth in that location. Organic matter, total nitrogen, total sulfur, and total soluble salt were up to three times higher in the surface 0-4.5 cm of Mesquite soil than in open soil but declined with increasing depths to levels approximately the same as in the open soil. Total potassium was enhanced under Mesquite but increased with depth (Malvi et al., 2021, Choudhary, 2020 and Khandagle et al., 2019). Total phosphorus and hydrogen ion awareness were similar to soil from open areas. Results suggested that Mesquite trees serve to ameliorate soil conditions under their canopies by redistributing nutrients from areas beyond the cover to areas beneath the cover.

The Aravalli Range, the oldest mountain range, stretches across the state of Rajasthan from Mount Abu (southeast) to Khetri in Jhunjhunu district (northeast). It divides the state into 60% in the northwest and 40% in the total carbon and nitrogen in the soil under the canopies of *Acacia senegal* and *Balanites aegyptiaca* trees, impacting tree growth. Soil nutrients undergo changes over time with the occupancy of woody plants in a given patch. Generally, soil nutrient concentrations tend to decrease with increasing soil depth. However, there is substantial evidence of a significant reserve of nitrate-nitrogen at greater depths in groundwater in arid zones. The average values of soil available PO₄-P, NH₄-N, and NO₃-N were 15.22 mg kg⁻¹, 3.82 mg kg⁻¹, and 2.43 mg kg⁻¹, respectively, across all sampling sites and soil layers (refer to Table 2). Regardless of soil layers, available PO₄-P ranged from 11.25 mg kg⁻¹ at Kanuja I to 18.30 mg kg⁻¹ at Phatakhera-I, while available NH₄-N varied from 2.55 to 2.15 mg kg⁻¹ at Phatakhera-I and 5.75 to 4.14 mg kg⁻¹ at Kotra-I. When considering different soil layers, these soil nutrients consistently exhibited higher concentrations in the topsoil compared to deeper layers, showing a decreasing trend with depth, except at Kanuja-III and Megarda-I. In Kanuja III, the availabilities of PO₄-P and NH₄-N were relatively greater in deeper soil layers compared to the topsoil layer. Megarda-I also showed higher concentrations in deeper soil layers. The soil in the Pali district is categorized as gray-brown alluvial soil, containing a substantial nitrate content that contributes to its fertility. The soil depth in the study area varies from nearly bare on hill covers to a few meters in foothills with scattered dunes. In certain areas, especially those adjacent to water bodies, the soil fertility is notable, supporting the growth of agricultural crops and vegetables with distinctive flavors, likely attributed to water quality and trace minerals. Thus, the available soil in the study area may serve as an indicator of the rock degradation pattern and the formation of soil that supports specific types of vegetation.

CONCLUSION

For a sustainable urban future, society must work towards the goal of efficient and judicious mineral use. Any country aspiring to develop its economy and improve living standards must secure a robust and active supply of mineral resources. As more countries emerge from poverty and bolster their economies, the demand for energy, supported by the supply of mineral resources, is bound to rise. The escalating factors of population growth, urbanization, and industrialization are exerting relentless pressure on the supply of ores, mineral resources, drinking water, and energy worldwide. Indiscriminate mining of large quantities of ores, rocks, minerals, placer deposits, and soil for domestic, commercial, and industrial purposes not only presents immediate challenges but also generates long-term consequences that may impact future generations and instill a sense of global insecurity. Soil pollution poses a significant threat to human health, even in urban areas, as the quality of soil deteriorates due to various inorganic and organic contaminants. This issue is not only an ecological risk but also a socio-economic challenge. Polluted soil becomes deficient in physicochemical properties, prone to erosion, lacking in productivity, sustainability, and diminished food chain quality-critical factors for human society. Materials such as granite, dolomite, migmatites, limestone, quartzitic schist, and Bar conglomerates mica schist, which can be utilized for





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making tiles, slabs, and pillars, are in high demand in both rural and urban areas. Additionally, soil, sand, concrete, cobble, pebble, and boulders are already being used for masonry works, generating considerable revenue. However, it is now crucial to curb the exploitation of natural resources and control the unnecessary consumption of modern comforts and luxuries for the economic development of our country. The primary objective of this paper is to advocate for responsible management of soil, water, and mineral resources, lest future generations bear consequences for actions without cause. This paper emphasizes that mineral resources vary from soil to soil, dependent on distinct intensity levels found in the soil, and these minerals are derived from parent rock materials.

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Table 1: Lithostratigraphy of the Phatakhera-Megarda-Bhilan-Kanuja-Kotra section of rock formation.

Heron (1953)	Under Present Study	
Intrusive granite	Intrusive granite	
Sendra Complex	Sendra Formation	Calc gneiss with intercalated quartzite
		Metamorphosed limestone
		Calc amphibolite gneiss
		Foliated quartzite
		Calc gneiss
Nandana Crystalline Limestone	Dolomite	
Barotiya Sequence	Barotia Formation	Quartzite schist
		Calc amphibolite schist
	Bar Conglomerate Horizon	Kyanite Schist
		Staurolite schist
		Garnetiferous mica schist
		Bar conglomerate schist
		Quartzofeldspathic schist and conglomerate
Unconformity	Unconformity	
(B.G.C) Granitic gneiss	(B.G.C) Granitic gneiss	

Table 2. Soil content for vegetation study around Phatakhera-Megarda-Kanuja-Kotra villages Raipur tehsil Pali District, Rajasthan.

Sampling site	Soil depth (cm)	Soil nutrients (mg kg ⁻¹)		
		PO ₄ - P	NH ₄ - N	NO ₃ - N
Phatakhera I	0-15	18.30	2.55	1.80
	15-80	18.99	2.15	1.05
Phatakhera II	0-30	9.10	5.50	2.05
	30-75	12.80	5.20	1.80
	75-100	18.10	4.70	1.05
Megarda I	0-10	12.80	5.55	3.90
	10-30	9.16	4.08	2.09
	30-80	16.67	3.68	2.95
Megarda II	0-25	21.26	4.90	2.75
	25-80	11.25	4.30	1.95
	80-100	13.68	3.77	2.09
	100-110	12.25	3.90	1.92
Bhilan I	0-10	19.85	4.99	3.99
	10-50	12.30	4.86	1.95
	50-70	9.69	2.85	2.95





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Bhilan II	0-10	14.26	3.72	1.65
	10-180	12.82	2.88	1.92
Kanuja I	0-60	11.25	3.52	2.70
Kanuja II	0-20	22.14	4.59	3.70
	20-40	13.99	3.77	2.39
	40-70	15.51	1.93	0.71
Kanuja III	0-30	19.28	2.95	3.86
	30-60	19.78	2.83	2.91
	60-90	15.20	2.84	1.36
	90-180	13.44	2.95	3.86
Kotra I	0-10	18.36	5.76	4.77
	10-50	16.44	4.14	2.64
Kotra II	0-10	17.67	4.12	2.78
	10-100	16.33	3.56	1.89
	100-140	14.22	2.32	1.54

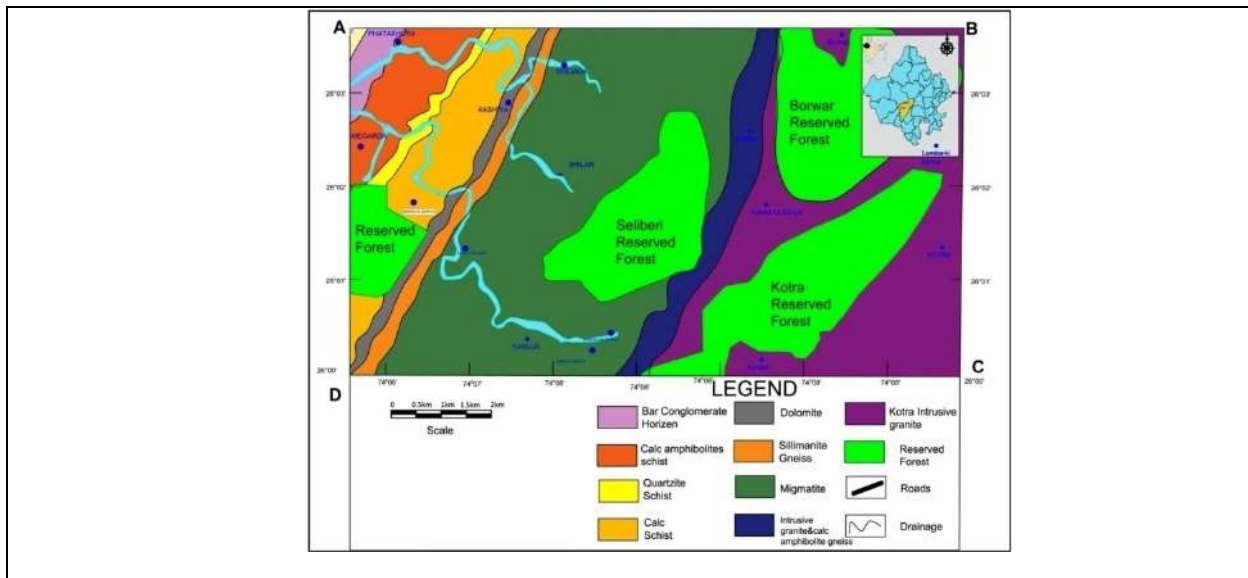


Figure 1: Geological map of Phatakhera-Megarda-Kanuja-Kotra villages Raipur tehsil Pali District, Rajasthan.





Assessment of Awareness, Attitude, and Practices of University Students on Solid Waste Management in the State of Andhra Pradesh

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ABSTRACT

Developing a comprehensive solid waste management (SWM) programme needs analysis and improvement of awareness, attitude and practice on different aspects of SWM. The present descriptive study is an assessment of existing level of awareness, degree of attitude, and extent of practice on solid waste management (SWM) among university students in the state of Andhra Pradesh in South India and the results unveiled that the general level of awareness of SWM among students is moderate. It also revealed that the degree of attitude of students towards SWM is much greater whereas the extent of practice of SWM is moderate among students. Further, it revealed that gender has significant influence on the awareness of students with respect to SWM rules, community participation and other aspects only, but not in the case of SW minimisation, collection & segregation, disposal and overall awareness of SWM. As regards the attitude, the results reveal that gender has significantly influenced the attitude of students towards overall SWM and the dimensions with respect to collection & segregation, community participation, disposal, transport and other aspects only but not the SWM rules and SW minimisation. Regarding the SWM practices, the results reveal that gender has significant influence on the practices of students with respect to overall SWM and the dimensions refuse & reduce, reuse & recycle only, but not in the case of collection, segregation, transport and disposal.





Keywords: Waste management, university students, awareness, attitude, practice, gender.

INTRODUCTION

Solid waste management (SWM) has emerged as one of the most massive development challenges in India. Numerous studies indicate that the unsafe disposal of waste generates dangerous gases and leachates, due to microbial decomposition, climate conditions, refuse characteristics and land-filling operations. India has already exhausted all available landfill sites, and the concerned ULBs do not have resources to acquire new land (Namita Gupta and Rajiv Gupta, 2015). Various legislations have been passed for regulating the manner of waste disposal. The Ministry of Environment, Forest and Climate Change (MoEFCC) and the Ministry of Housing and Urban Affairs (MoHUA) have together rolled out policies and programmes to address these issues. However, most of these have failed to achieve their objectives due to a lack of clarity and awareness amongst the stakeholders, and poor enforcement by the regulators (Shyamala Mani and Satpal Singh, 2016). On October 2, 2014, Swachh Bharat Abhiyan was introduced nationwide to address issues with solid waste management and hygienic conditions (Jangra et al., 2016). Higher education institutions have long been viewed as both centres of learning and catalysts for social and political transformation. HEIs expand the frontiers of knowledge in addition to educating decision-makers. They have a considerable economic impact both domestically and internationally because they are important employers and consumers of goods and services (UNEP, 2011). One of the main problems of HEIs is waste management. As the number of students increases each year, the amount of waste generated every day also increases. Therefore, Ministry of Human Resource Development, GOI, initiated Swachh Campus for Higher Education Institutions (HEIs) and Universities, which mirrors the principles of green institutions and endeavors to extend learning beyond the classroom to inculcate and develop responsible attitude, habits and lasting commitment to Swachhta, be it at home, on the campus or in the wider community. Students must have awareness about environmental problems so that they can play their role very effectively in proper waste management (Tartiu, 2011).

Nikhat Parvez, Avlokita Agrawal, and Akhilesh Kumar (2019) in a study on "Solid Waste Management on a Campus in a Developing Country: A Study of the Indian Institute of Technology Roorkee " reported that there were some areas without dustbins, that there was no waste segregation in the academic buildings, and that occasionally garden waste (leaves and weeds) was burned in some places. Starovoytova and Namango's (2018) study also found that the university's current SWM system is largely unacceptable and the investigation has demonstrated, in particular, that the university's open and unregulated waste dumpsite makes all environmental degradation, health effects, and safety violations highly likely. Mark Joseph Tamba Reyes & D.V. Madrigal (2020) in a study on 'Assessing Students' Awareness, Attitude, and Practices on Solid Waste Management in a Philippine Catholic School' found that students exhibited a high level of awareness, a very Favourable attitude, and a great extent of practice on SWM regardless of sex(Cited in Mark Joseph Tamba Reyes & D.V. Madrigal, 2020). Though many measures were made, the HEIs still need to develop a comprehensive program on solid waste management to give a solution to the problem permanently. To date, however, there is a dearth of substantial evidence supporting the extent to which students have internalized and practiced the environmental concepts. To develop a comprehensive swm programme, finding out and improvising students' awareness, attitude and practice on different aspects of swm is important. Systematic research is thus, necessary to identify the swm awareness, attitude and practice to help the educators and planners to develop suitable content for environmental education and training programmes with special reference to swm for the students as well as educators. The present study is a limited attempt to assess the swm awareness, attitude and practice of university students in the state of Andhra Pradesh to initiate and develop suitable strategies.

Objectives of the study

1. To assess the level of awareness, degree of attitude and extent of practice of SWM among university students of Andhra Pradesh State.



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2. To find out the significant difference if any, in the awareness of SWM among university students due to variation in their gender.
3. To find out the significant difference if any, in the attitude of university students due to variation in their gender.
4. To find out the significant difference if any, in the practice of SWM among university students due to variation in their gender.

Hypotheses of the Study

1. There exists no significant difference in the awareness of SWM among university students due to variation in their gender.
2. There exists no significant difference in the attitude towards SWM among university students due to variation in their gender.
3. There exists no significant difference in the practice of SWM among university students due to variation in their gender.

METHODOLOGY

For the present study descriptive survey method was used. The sample group of the research consisted of a total of 590 students from 13 universities were selected by using Stratified Random Sampling Method. The researchers developed the tools with structured statements and validated to assess the students' awareness, attitude and practice on SWM: 1) Solid Waste Management Awareness Scale (SWMAS), 2) Solid Waste Management Attitude Scale (SWMATS) and 3) Solid Waste Management Practice Scale (SWMPS). The SWMAS consists of 20 items. The items were distributed under six dimensions viz., SWM rules, SW minimization principles, collection & segregation, disposal, community participation and other aspects. The dimensions have 3,3,4,3, 2 and 5 items respectively. Each item has three alternate responses viz., Fully Aware, Aware to Some Extent and Not Aware. Pilot study has been conducted to test suitability of the items. The reliability of this tool was found as 0.79. The tool has content validity, intrinsic validity and face validity. The SWMATS consists of 26 statements. The statements were distributed under six dimensions viz., SWM rules, SW minimization principles, collection & segregation, disposal, community participation, disposal, transport and other aspects. The dimensions have 3,4, 6, 3, 3, and 7 items respectively. Each item has five alternate responses viz. strongly agree, agree, undecided, disagree, strongly disagree. Pilot study has been conducted to test suitability of the items. The reliability of this scale was found as 0.77. The tool has content validity, intrinsic validity and face validity. The SWM practice scale consists of 26 items and was distributed under four dimensions viz., SW minimization, collection & segregation, SW disposal, and transportation & others. The dimensions have 10, 5, 5, and 6 items respectively. Each item has three alternate responses viz. Always, Sometimes and Never. Pilot study has been conducted to test suitability of the items. The reliability of this tool was found as 0.81. The scale has content validity, intrinsic validity and face validity. Statistical Techniques Used: Percentage (%), Mean, Standard Deviation and t- test

DATA ANALYSIS AND INTERPRETATION**Levels of Awareness of SWM among Students**

For the purpose of categorizing the university students under different levels of awareness, the investigators computed the values of Mean + σ and M - σ based on the total scores obtained by the students. The obtained values of Mean + σ and M - σ are 32.76 and 19.3 respectively. The students who scored greater than or equal to the value of Mean + σ were considered as students having 'Fully Aware', the students who scored less than or equal to the value of M - σ were considered as having 'Not Aware' and the students who scored between the values of Mean + σ and M - σ were considered as having 'Aware to some Extent'. The frequency and percentage of students identified at different levels of SWM awareness are shown in the Table No. 1. Out of the sample of '590', the students are categorized in to three levels based on the frequencies and percentages such as '16% are not aware of SWM, 67% are aware of SWM to some extent and 17 % students are fully aware of SWM. It implies that a majority of university



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students are aware of SWM to some extent. But, only 17 % of students are aware of all the dimensions of SWM such as SWM rules, SW minimisation, collection & segregation, disposal and community participation, transport and other aspects. This may be due to non-exposure of students to complete cycle of the SWM process or lack of participation of students' participation in these activities. Further, the results also indicate that only 16% of students expressed less level of awareness. It contradicts the results of Kofi Debrah , Diogo Guedes Vidal and Maria Alzira Pimenta Dinis (2021) , Mark Joseph Tamba Reyes & D.V. Madrigal (2020), and Margarita C. Paghasian (2017) which showed high level of awareness of swm among students. The results also contradict with the results of Ifegbesan (2010) and Alfredo P. Nabor Jr., Ruth A. Ortega-Dela Cruz (2022) which reveals low level of pupils' awareness. The low level of awareness of students on solid waste management can be attributed to lack of information they gain from the university and at home about SWM with regard to waste collection, segregation and disposal. This further implies that much amount of concern, responsiveness, and efforts need to be done by the administrators and faculty to promote better waste management.

Degree of students' Attitude towards SWM

For the purpose of categorizing the university students based on their degree of attitude towards SWM, the investigators computed the values of Mean + σ and M - σ based on the total scores obtained by the students. The obtained values of Mean + σ and M - σ are 105.07 and 80.99 respectively. The students who scored greater than or equal to the value of Mean + σ were considered as students having 'Favourable Attitude', the students who scored less than or equal to the value of M - σ were considered as having 'Unfavourable Attitude' and the students who scored between the values of Mean + σ and M - σ were considered as having 'Neutral Attitude'. The frequency and percentage of students identified at different degrees of attitude towards SWM are shown in the Table No. 2. Out of the sample of '590', around 17 % , students expressed Unfavourable attitude towards SWM, around 68 % are neutral whereas around 15% students expressed Favourable attitude towards SWM. It indicates that a majority of students are possessed with neutral attitude towards SWM. The results contradict the findings of Kofi Debrah, Diogo Guedes Vidal and Maria Alzira Pimenta Dinis (2021) which suggests that students at both secondary and tertiary levels have Favourable environmental attitudes, Desa et al. (2012), which showed that pupils have a high level of attitude and the results of Alfredo P. Nabor Jr., Ruth A. Ortega-Dela Cruz (2022) which reveals low level of pupils' attitudes towards SWM. A smaller number of students have Favourable attitude and this may be because students were not sensitized on different components of SWM so as to develop a Favourable attitude towards SWM and thereby help them adopt suitable practices for effective solid waste management.

Extent of Practice of SWM among Students

For the purpose of categorizing the university students, based on extent of their practice, the investigators computed the values of Mean + σ and M - σ based on the total scores obtained by the students. The obtained values of Mean + σ and M - σ are 43.19 and 28.37 respectively. The students who scored greater than or equal to the value of Mean + σ were considered as students practicing in SWM to the maximum extent, the students who scored less than or equal to the value of M - σ were considered as students practicing in SWM to the least extent and the students who scored between the values of Mean + σ and M - σ were considered as practicing in SWM to the moderate extent. The frequency and percentage of students identified at different levels of SWM practice are shown in the Table No. 3. Out of the sample of '590', the investigators observed the 17% are practicing SWM to the least extent, 16 % are practicing to the maximum extent and remaining 67% of students are practicing to moderate extent. The results contradict with the results of Alfredo P. Nabor Jr., Ruth A. Ortega-Dela Cruz (2022) and Ifegbesan (2010) which shows low level of practice of swm by students, and Margarita C. Paghasian (2017) which reveals that the students' practices in terms of segregation, reduce and recycle were good; and their practices in terms of recycle and disposal were fair, Desa et al. (2012), which showed that pupils have a high level of practices regarding solid waste management program. This implies that most of the students practice SWM to the moderate extent only and a smaller number of students practice it to the maximum extent. As an institution committed to providing quality Education which includes concern about the environment, the integration of SWM topics is an essential indicator in the promotion of better SWM practices. This is a desirable step in warranting a better and safe environment and promoting the community's common good. Mark Joseph Tamba Reyes & D.V. Madrigal (2020) found a great extent of practice on SWM .





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Influence of Gender on Awareness, Attitude and Practice Scores of Students:

As the distribution follows normality, parametric tests of significance such as 't' was applied to study the significance of the influence of gender on the awareness, attitude and practice of SWM among university students. The hypotheses 1- 3 have been tested on appropriately selected groups – male and female students – to assess the significance of the influence of gender on the awareness, attitude and practice of SWM among university students and the results are presented in Table no 4- 6. From table 4, it is seen that the obtained t- value is significant at 0.05 level with regard to the dimensions SWM rules (t, 2.208), community participation (t,1.987), transport and others (t ,2.381) indicating the influence of gender on the students' awareness of SWM. Hence, the formulated null hypothesis is rejected in the case of SWM rules, community participation, transport and others only. Thus, it is concluded that gender has significantly influenced the awareness of students with respect to SWM rules, community participation, transport and other aspects only, but not the SW minimisation, collection & segregation, disposal and overall awareness of SWM. From the results, it is observed that female students exhibited higher means, which indicates that the female students are more aware of solid waste management compared to male respondents respectively. Mark Joseph Tamba Reyes & D.V. Madrigal (2020), Madrigal and Oracion (2017), Do Paco, Raposo, and Leal Filho (2009), Garcia and Luansing (2016), Adeolu, Enesi, and Adeolu (2014), and Guido and Lim (2015) indicated in their studies that females are more conscious about solid waste management than males (Cited in Mark Joseph Tamba Reyes & D.V. Madrigal, 2020). But contradicts with the results of Tatlonghari and Jamias (2010) which reports that gender is not an influencing factor of male and female students in their awareness of SWM. It is seen from the table-5 that the obtained t- value is significant at 0.01 level with regard to overall attitude towards SWM (t, 5.723) and the dimensions collection & segregation (t, 4.183), community participation (t, 3.442), disposal (t, 3.697), and transport and others (t, 5.266) indicating the influence of the gender on the attitude of university students towards SWM. Hence, the formulated null hypothesis is rejected in the case of collection & segregation, community participation, disposal, transport and others and overall attitude towards SWM. It is concluded that sex has significantly influenced the attitude of students towards overall SWM and the dimensions with respect to collection & segregation, community participation, disposal, transport and other aspects only, but not in the case of SWM rules and SW minimisation. According to demographics, students also showed a very Favourable attitude towards solid waste management regardless of gender. Female students exhibited higher means, which implies that in terms of gender, female students have more possibility to have a Favourable attitude towards solid waste management. Moreover, the findings validated the study of Madrigal and Oracion (2017); and Adeolu (2014); Raudsepp (2001), which emphasized that female students could be said to have Favourable waste management attitude than their male counterpart (Cited in Mark Joseph Tamba Reyes & D.V. Madrigal, 2020) but contradicts the results of Tatlonghari and Jamias (2010) which reports that gender is not an influencing factor of male and female students in their attitude towards SWM. Table-6 clearly reveals that t- values are significant at 0.05 level with respect to overall SWM practices (t, 2.281), and with respect to the dimensions refuse & reduce (t, 2.4), and reuse & recycle (t ,2.21). Hence, the formulated null hypothesis is rejected in the case of refuse & reduce, reuse & recycle, and overall practice of SWM. Hence, it is concluded that gender has significantly influenced the practices of students with respect to overall SWM and the dimensions refuse & reduce, reuse & recycle only, but not the SWM collection, segregation, transport and disposal. The results contradict the findings of Tatlonghari and Jamias (2010) which reports that sex is not an influencing factor of SWM practice among male and female students. Nikhat Parvez, Avlokita Agrawal and Akhilesh Kumar, (2019) also found that improper collection, imprecise segregation, exposed transportation, inefficient processing and disorganized disposal of solid waste are the major reasons for disorganized and incompetent SWM at IIT, Roorkee.

FINDINGS OF THE STUDY

1. Students expressed moderate level of awareness of SWM in general.
2. Students expressed Favourable attitude towards SWM in general.
3. The extent of practice of SWM among students is moderate.
4. Gender has a significant influence on the awareness of SWM of university students, limited to SWM rules, community participation and other aspects only, but not on the other dimensions viz., SW minimisation, collection & segregation, disposal and overall awareness of SWM.



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5. Gender has significantly influenced the attitude of university students towards overall SWM and the dimensions with respect to collection & segregation, community participation, disposal, transport and other aspects only, but not the other dimensions such as SWM rules and SW minimisation.
6. Gender is an influencing factor of the practices of students with respect to overall SWM and the dimensions refuse & reduce, reuse & recycle only, but not the other dimensions viz., collection, segregation, transport and disposal.

CONCLUSION

From the results of the study, it is implied that students still need to be educated on the issue of solid waste management from a variety of angles, including community involvement, transportation, collection and segregation, disposal, and SW minimization. This will help to increase their awareness of the issue and encourage them to support the implementation of the waste management strategies required to keep the campus clean. Even though the kids show a Favourable attitude towards solid waste management, it is still necessary to teach them about appropriate behaviour in this regard. Therefore, it is recommended that administrators create a solid waste management programme that includes education, attitude, and practice activities to help university members develop environmentally friendly solid waste management practices, promote moral behaviour, and create a comprehensive awareness of the subject in the direction of a more sustainable, healthy, and safe university campus. Additionally, educators can host lectures on solid waste management; incorporate SWM into performance tasks and projects; organise clean-up campaigns; host environmental exhibits and competitions; and run other pertinent programmes that raise awareness of environmental issues and actively involve teachers and students in finding solutions to solid waste management-related problems. Green clubs ought to be established in order to guarantee Green Campuses in university settings, as recommended by UGC. These clubs ought to buy additional trash cans and place them in noticeable locations where students can readily dispose of their waste correctly, such as beside walkways or under every covered space.

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Table-1: Table Showing Levels of Awareness of SWM among Students

Levels of Awareness of SWM among Students	Number and Percentages of students	
	Frequency	Percentage
Not Aware	94	16%
Aware to some Extent	396	67%
Fully Aware	100	17%
Total	590	100%

Table-2: Table Showing Degree of Attitude of Students towards SWM

Degree of Attitude of Students towards SW	Number and Percentages of students	
	Frequency	Percentage
Unfavourable Attitude	100	16.95%
Neutral Attitude	401	67.97%
Favourable Attitude	89	15.09%
Total	590	100%

Table-3: Table Showing Extent of Practice of SWM among Students

Extent of Practice of SWM among Students	Number and Percentages of students	
	Frequency	Percentage
Least Extent	100	17%
Moderate Extent	396	67%
Maximum Extent	94	16%
Total	590	100%





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Table-4: Table showing N, Mean, S.D and t-values of SWM Awareness scores of male and female students

Dimensions	Gender	N	Mean	Std. Deviation	t-Value	Sig
SWM Acts/Rules	Male	210	3.26	1.658	2.208	*
	Female	380	2.94	1.741		
SW minimization	Male	210	4.12	1.310	0.243	@
	Female	380	4.15	1.417		
SW Collection and Segregation	Male	210	5.35	1.869	0.969	@
	Female	380	5.50	1.715		
SWM & Community participation	Male	210	2.64	1.081	1.987	*
	Female	380	2.83	1.117		
SW Disposal	Male	210	3.42	1.699	0.289	@
	Female	380	3.38	1.735		
Others	Male	210	6.95	2.273	2.381	*
	Female	380	7.39	2.034		
Total	Male	210	25.75	6.703	0.746	@
	Female	380	26.18	6.751		

Note: *; Significant at 0.05 level; and @; not significant at 0.05 level.

Table-5: Table showing N, Mean, S.D and t-values of SWM Attitude scores of male and female students

Dimensions	Gender	N	Mean	Std. Deviation	t-value	Sig
SW Acts/Rules	Male	210	11.32	1.861	0.260	@
	Female	380	11.80	1.645		
SW minimization	Male	210	13.43	2.249	1.825	@
	Female	380	13.78	2.177		
SW Collection and Segregation	Male	210	20.79	3.686	4.813	**
	Female	380	22.19	3.229		
SW & Community participation	Male	210	10.54	2.091	3.442	**
	Female	380	11.20	2.288		
SW Disposal	Male	210	7.71	3.118	3.697	**
	Female	380	8.66	2.907		
SW Transport and Others	Male	210	25.52	4.500	5.266	**
	Female	380	27.45	4.129		
Total	Male	210	89.31	12.121	5.723	**
	Female	380	95.08	11.508		

Note: *; Significant at 0.05 level; @; not significant at 0.05 level, **; Significant at 0.01 level





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Table-6: Table showing N, Mean, S.D and t-values of SWM Practice scores of male and female students

Dimensions	Gender	N	Mean	Std. Deviation	t-value	Sig
Refuse & Reduce	Male	210	13.78	3.307	2.400	*
	Female	380	14.40	2.816		
Reuse & Recycle	Male	210	6.74	2.027	2.210	*
	Female	380	7.11	1.877		
SW Collection & Segregation	Male	210	6.71	2.015	0.630	@
	Female	380	6.82	1.945		
SW Transport & Disposal Others	Male	210	7.62	2.639	1.614	@
	Female	380	7.97	2.509		
SWMPS SCORE	Male	210	34.85	7.932	2.281	*
	Female	380	36.30	7.056		

Note: *; Significant at 0.05 level and @ : Not Significant at 0.05 level





Biomimetic Materials : A Review

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ABSTRACT

Biomimetics: Can be defined as fabrication of novel materials with remarkable mechanical properties. The words bio and memesis are derived from Greek words meaning life & imitation. The study of biomimetics translates our knowledge of biological structures & their functions to produce new synthetic pathways to emulate biological processes. In this article a detailed review is done on most commonly used biomimetic materials in dentistry. These are the materials that have excellent physicochemical properties along with being biocompatible. A detailed study can provide a basis for material selection in diverse cases.

Key words: biomimetic, biocompatible, mimic, biomaterials

INTRODUCTION

In dental medicine the concept of Biomimetic Material biomimetic is an increasingly applicable word especially in restorative dentistry. The secondary meaning of biomimetics refers to mimicking or recovery of the original tooth both in form as well as function. Biomimetic dentistry is a philosophy that teeth needing restoration should be rebuilt if possible to The invention of glass ionomer cement in 1969 (Qirst mimic clearly the form and the function of the original reported by Wilson and Kent in1971) resulted from design[1].

The following materials can be considered as biomimetic materials:

- Glass ionomer cements
- Calcium hydroxide
- Mineral Trioxide Aggregate



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- Calcium sulphate
- Bioactive glass
- Emdogain
- Composites
- Ceramics
- Biodentine

Glass Ionomer Cement

The invention of this cement is from basic studies on dental silicate cements where the phosphoric acid was replaced by organic chelating.

Reinforced Glass Ionomer Cement

The design of the original glass ionomer cements was a hybrid formulation of silicate and polycarboxylate cements. The earliest commercial product was class III/V cavities as an alternative to glass ionomers.

Attempts to further improve the strength of the glass ionomers or composites led to the incorporation of metallic oxide and metal alloy fillers by Seed and Wilson in 1980, but these cements known as MIRACLE MIX had poor wear resistance. Later McLean and Gasser in 1985 overcame this problem by fusing silver particles onto glass – 'CERMETS' rendering better wear resistance, smoother surface radiopacity, but had poor esthetics.

Further development led to the introduction of RESIN version of conventional glass- ionomer that is mixed as a MODIFIED GLASS IONOMER OR HYBRID CEMENTS by Mathis and Ferracane in 1989. In these cements the glass ionomers were reinforced by incorporation of resins and the fundamental acid base curing reaction is supplemented by a second polymerization curing process, which is initiated by light (DUALCURE) or both i.e. light and chemical (TRICURE). HEMA (Hydroxy Ethyl Methacrylate) is the hydrophilic ionomer used in the liquid component of resin modified glass ionomers, so that the final restorations have 4.5-6% resin.

Continued evolution produced the Polyacid modified resin composites (compomers- a misnomer), these materials were introduced in 1993 from manufacturers efforts to improve and combine the best properties of glass ionomers and composite resins. The earliest term for these systems was 'isosit' (combining the terms ionomers and composite), but it was trademarked by a single manufacturer. The industry adopted the alternative arrangement of combined terms (composite and ionomers) which is now known as POLYACID MODIFIED COMPOSITE RESINS. [7].

The main usage of these cements is in Class III/V restorations in place of composites.

Composition**Powder**

∑ Silica (SiO₂) :
30.1%

∑ Alumina (Al₂O₃)
19.9%

∑ Aluminium Fluoride (AlF₃)
2.6%

∑ Calcium Fluoride (CaF₂)
34.5%

∑ Sodium Fluoride (NaF)
3.7%

∑ Aluminium phosphate (Al₃PO₄)
10%





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Modifications in Powder

Some of the modifications of powder are:

- Σ Dried Polyacrylic Acid (Anhydrous GIC)
- Σ Silver Tin Alloy (Miracle mix)
- Σ Silver Palladium/Titanium mix (Cermet Cement)
- Σ BISGMA, TEGMA and HEMA (Light Dual Cure)

Liquid

The percentage composition of glass ionomer liquid is

- Σ POLYACRYLIC ACID+ITAIONIC ACID 40-50%
- Σ TARTARIC ACID 15%
- Σ WATER 30%

Classification of Glass Ionomer Cements

Type 1: for luting

will craze and crack as a result of desiccation. Uses: cementation of crowns, bridges, inlays etc

Type 2: for restorative

Physical Properties of Glass Ionomers [10]

Type 2.1 -for aesthetic restorations Glass ionomers are rapidly setting cements Uses – class III, class V cavities, tunnel times in the range of 3-8 minutes. Working time should not exceed 45s. They have high compressive strengths.

Type 2.2 – for restorations requiring which may range from 200-400Mpa but are weak in reinforcement Qlexure [5-40Mpa].

Uses – core buildups

Type 3: for liner and base applications

Uses: Low powder: liquid ratio for liners, High Aesthetics: The glass component of glass ionomers

powder: liquid ratios for bases beneath amalgam provides the translucency for the material glass and composite ionomers provide the translucency for the material.

More recently, one more classification for glass Adhesion: Glass ionomers have the important property of permanently adhering to the untreated enamel and Type I- Luting dentin. They also bond to the polar substitutes like base. Type II- Restorations metals.80% of the bond strength is developed in the

Type III- Liners and bases Qirst 15 min of cement application and for this purpose Type IV- Qissure sealants cement should be applied immediately after mixing Type V- Orthodontic cementation without delay.

Type VI- Core build up

Type VII- Intermediate restorations Dissolution and Erosion: Chemical erosion by acids

Type VIII- Atraumatic Restorative Techniques (for generated by plaque or external agents like food and beverages has been found to be less for glass ionomers

Type IX- Atraumatic Restorative Techniques (for than other cements posteriors)

Chemistry of Setting: When the powder and liquid are of thermal expansion of conventional glass ionomer mixed to form a paste, the acid etches the surface of the cements is close to that of dentinal hard tissue and has glass particles and calcium, aluminum, sodium and been cited as a significant reason for the good margin Qluorine ions are leached into the aqueous glass ionomer.

The polyacrylic acid chains are cross-linked by the Coefficient of Thermal Expansion: Glass ionomer has calcium ions within the next 24 hours. Sodium and a linear co-efficient of thermal expansion (10^{-11}), Qluorine ions do not participate in the cross linking of similar to that of tooth structure (11.4×10^{-6}).





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Biocompatibility

Freshly mixed glass ionomer cements are acidic (pH 0.9-1.6) and it rises rapidly within the first 20min to reach a pH of 5.5-6 as the polysalt formation takes place.

Disadvantages

- Susceptible to dehydration over lifetime
- Sensitivity to moisture at placement.
- Poor abrasion resistance
- Average esthetics
- Less Tensile strength than composites
- Technique sensitive powder to liquid ratio and mixing.

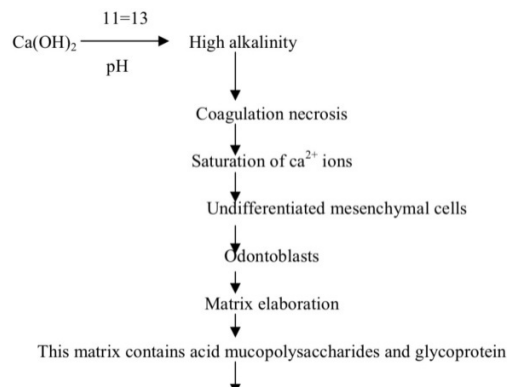
Calcium Hydroxide

Calcium hydroxide was introduced to dentistry by Hermann at the beginning of the 20th century and since then it has been widely used in endodontics. It is a strong alkaline substance with a pH of approximately 12.5 and has various biologic properties that prompted its use in several clinical situations. Its dental use relates chiefly to its antibacterial properties and the ability to induce repair and to stimulate hard tissue formation. The main benefit of calcium hydroxide as intracanal medicament lies in the bacterial effects conferred by its high pH as many endodontic micro-organisms are unable to survive in the highly alkaline environment provided by calcium hydroxide.[13]

Mechanism of action

Classification [14]

Can be classified as setting or non setting.



The former is used for lining or sublining of cavities or as root canal sealers, and the latter is used for dressing setting materials eg DYCAL, REOCAP, PROCAL.

Non setting materials

Disadvantages

1. Variability of treatment.
2. Unpredictability of apical closure.
3. Difficulty in patient follow up.
4. Delayed treatment.
5. Canal is susceptible to fracture during treatment.
6. Ca(OH) doesn't adhere to dentin and lack the ability to seal.



**Suneeth Shetty****Mineral Trioxide Aggregate**

MTA is a new material developed for endodontics that appears to be a significant improvement over other materials. Ever since its introduction by Torabinejad and colleagues in 1993 it has been used in both surgical and nonsurgical applications. It is the first restorative material that consistently allows for the overgrowth of cementum and it may facilitate the regeneration of the periodontal ligament.

Advantages [19, 20]

1. Resistance to marginal leakage reduces bacterial migration.
2. Least toxicity of all the filling materials.
3. Excellent biocompatibility.
4. Hydrophilic sets in the presence of moisture. Moisture contamination is not an issue.
5. Negligible Solubility
6. Super Sealing ability
7. Sufficient compressive strength to allow condensation of amalgam when it is used as pulp capping agent.
8. Reasonably radio opaque.

Disadvantages

1. Difficult to manipulate.
2. Prolonged setting time.
3. Dissolves in acidic pH.

Properties [23]

1. MTA has a pH of 10.2 initially and has a pH of 12.5, 3 hours after mixing. This may impart some antimicrobial properties.
2. The material has low solubility.
3. It has a radiopacity slightly greater than that of dentin.
4. It is less cytotoxic than other root end filling materials, it is biocompatible.
5. Its water based chemistry allows normal setting in the presence of moisture and blood.

Types

- a. MTA is supplied as a grey powder ProRoot MTA. The manufacturer recommends that it should be mixed with sterile water into a thick grainy paste. It can be mixed with anaesthetic or other sterile liquids.
- b. Tooth coloured white ProRoot MTA is also available with easy clinical manipulations.

Composition

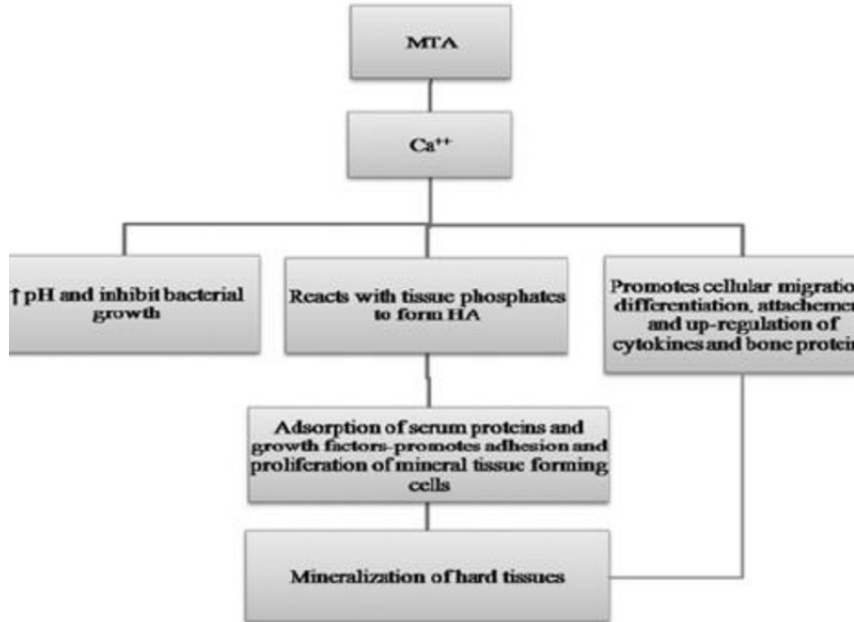
Mineral trioxide aggregate is a powder consisting of fine hydrophilic particles of:

1. Tricalcium silicate (Ca_3SiO_5)
2. Bismuth oxide powder is added for powder opacity.
3. Dicalcium Silicate ($2\text{CaO}\cdot\text{SiO}_2$)
4. Tricalcium Aluminate ($3\text{CaO}\cdot\text{Al}_2\text{O}_3$)
5. Calcium Sulphate (CaSO_4)
6. Tetracalcium alumino ferrite ($4\text{CaO}\cdot\text{Al}_2\text{O}_3\cdot\text{Fe}_2\text{O}_3$)
7. Tricalcium Oxide
8. Silicate Oxide





Mechanism of Action



Clinical Applications of Mineral Trioxide Aggregate [24,27,28]

It has usage in both surgical and non-surgical procedures

- 1) Direct pulp capping and pulpotomy
- 2) Apexification
- 3) Repair of root perforations (surgically and non-surgically)
 - a) Lateral perforation.
 - b) Furcation perforation
 - c) Strip perforation.
- 4) Root-end filling
- 5) MTA can also be used for repair of perforation due to internal resorption.

Calcium Phosphate

Researchers have shown that calcium phosphate ceramic biomaterial are effective for a variety of the following:

Restorative

Preservative clinical applications

Calcium phosphate ceramics such as hydroxyapatite and beta tricalcium phosphate possess a mineral composition very close to that of normal bone. The composition makes it useful in bone substitution

Emerging dental applications

To fill oversized osteotomies for implants

Craniofacial reconstructions

Interpositional grafting procedures

As a coating around the metallic implants

Calcium Sulfate

It is a material that has been widely used in endodontic practice for the treatment of numerous bone lesions as well as in implantology.





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It can be used both as a barrier and hemostatic material in perforation management. Calcium sulfate creates a tamponade effect mechanically plugging the vascular channels once it sets. It is remarkably biocompatible does not promote inflammation and is bioresorbable in 2-4 weeks.

Bioactive glass

Bioactive glass (BAGs) first introduced by Hench et al are surface active glasses that bond chemically to bone materials. They are non-bone graft materials. These bioactive glasses contain different ratios of Na₂O(24.5%), CaO (24.5%) P₂O₅ – SiO₂ (45%). The bonding of BAGs to living bones is achieved through a bone like apatite layer forming on their surface in the body environment owing to their strong bond with living bone, BAGs have been used as a bone substitute materials in different clinical conditions [31]. The commercially available glass for the application in bone sites is, Bioglass with a particle size of 300-355µm.

Bone morphogenetic proteins [33]

In 1964, Marshall Urist discovered that bone which had been demineralized and dried into a powder could be implanted into the muscle of a rabbit and stimulate the growth of a new bone. Urist and collaborators later determined that the active component was proteinaceous and dubbed it bone morphogenetic proteins (BMP).

There are at least 15 BMP like molecules

BMP-1

BMP-2

BMP - 3 (Osteogenin)

BMP-4 etc

Osteoinductive (OP1)

Eight BMPs namely BMP-1-7 and osteogenic protein have so far been cloned and expressed.

Clinical applications

1. Direct pulp capping
2. Pulpotomy
3. Guided bone regeneration
4. Furcation repair
5. Dental implants

Resin based composites

These composites include

1. Smart composites
2. Ormocers
3. Ceromers

Smart materials: Tooth coloured restoratives which are cariostatic in nature by their inherent ability to leach fluoride are referred to as smart fluorides.

Classification

Passive smart materials:

These are materials that release ions into the oral cavity continuously with or without the necessity to prevent caries

Eg. Glass ionomer cement, Resin modified glass ionomer, Ceromers

Active smart material: These are materials, which can react favourably when there is a hazardous variation in the environment surrounding the restoration & in prevention of caries.

For instance: Smart composites

Smart composites: A new approach in restorative dentistry was the introduction of an ion releasing composite material in 1998.





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It is based on a new developed alkaline glass which aims at reducing secondary caries, reducing demineralization and buffering acid produced by micro-organisms, when the pH around the restorative material falls below 5.5, the material releases hydroxyl, calcium and Fluoride ions.

Mode of supply: It is available in unit dose capsules (caviQils) and in syringes. Uses of smart materials

Prosthodontics	✓ Smart impression material
Orthodontics	✓ Shape memory alloys
Pediatric and Preventive Dentistry	✓ Fluoride-releasing pit and fissure sealants, ACP releasing pit, and fissure sealants
Dental materials	✓ Smart composites ✓ Smart ceramics
Conservative Dentistry and Endodontics	✓ Ni-Ti rotary instruments ✓ Smart prep burs
Oral surgery	✓ Smart suture
Periodontics	✓ Smart antimicrobial peptide
Laser Dentistry [7]	✓ Smart fibers

Ormocers

It is the acronym of organically modified ceramic. It was developed by Fraunhofer institute for silicate research, Wurzburg in co-operation with partners from the dental industry in 1998.

They are new type of material which chemically are methacrylate substituted alkoxy sil. New multifunctional urethane and thioether (meth) acrylate alkoxy as sol-gel precursors have been developed for preparation of inorganic-organic co-polymers composites.

Composition

Ormocer matrix – Ceramic polysiloxane (silicon- oxygen chain)
Zirconium and glass fillers (1-1.5µm in size) o Coupling agents Eg. Admira Voco

Advantages

- Biocompatible
- Reduced polymerization shrinkage
- High abrasion resistance
- Esthetics
- Anticaries property
- Considered as one of the most promising alternatives to Amalgam.

CEROMERS

Ceramic optimized polymers

They are specific combination of the latest in ceramic filler technology and advanced polymer chemistry which provide enhanced function and esthetics. They are composed of specially developed and conditioned homogenous three dimensional fine particle ceramic fillers (0.04 -1mm) of submicrometer size which are densely packed (approx 80% in weight) and embedded in an advanced organic matrix with optimum light and heat curing potential.

e.g Targis / Vectris – Ivoclar

Composition

Barium glass
Spheroidal mixed oxide o Ytterbium trioxide





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BIS-GMA
Urethane dimethacrylate

Disadvantages of Dental Ceramics

1. BRITTLENESS:
2. TECHNIQUE SENSITIVE:
3. HIGH COST:
4. WEAR OF NATURAL TEETH:
5. DIFFICULT TO REPAIR INTRAORALLY

Properties of Dental Ceramics

Table 3. Physical and Mechanical properties of Dental Ceramics¹

Compressive strength	330 MPa
Diametral tensile strength	34 MPa
Transverse strength	62 - 90 MPa
Shear strength	110 MPa
MOE	69 GPa
Surface hardness	460 KHN
Specific gravity	2.2–2.3 gm/cm ³
Thermal conductivity	0.0030 Cal/Sec/cm ²
Thermal diffusivity	0.64 mm ² /sec
Coefficient of Thermal expansion	12 × 10 ⁻⁶ /°C

Fatigue strength plays an important role in the durability and longevity of dental ceramic restorations.

Classification

1. Sintered all ceramic materials.
Alumina based ceramics eg. Hi-ceram
Leucite-based ceramics eq. Optec HP
2. CASTABLE CERAMICS
3. PRESSABLE CERAMICS
Leucite –reinforced
Lithium disilicate reinforced Eg. IPS Empress 1, IPS Empress 2
4. Infiltrated/slip cast ceramics
Alumina-based ceramics • Spinel based ceramics
Eg. InCeram ad InCeram spinel
5. Machineable Ceramics
CAD-CAM systems
Copy-milling systems.
Eg. Cerec Vitablocs Mark 1, Cerec Vitablocs Mark

Biodentine™

Was developed by Septodont's Research Group, Several years of active and collaborative research between Septodont and several universities led to a new calcium-silicate based formulation, which is suitable as a dentin replacement material whenever original dentin is damaged, thus these materials are termed as biomimetic.





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Composition

Powder	Liquid
Tricalcium silicate ($3\text{CaO}\cdot\text{SiO}_2$)	Calcium chloride ($\text{CaCl}_2\cdot 2\text{H}_2\text{O}$)
Dicalcium silicate ($2\text{CaO}\cdot\text{SiO}_2$)	Hydrosoluble polymer
Calcium carbonate (CaCO_3)	
Zirconium dioxide (ZrO_2)	
Iron oxide	

Setting Reaction [41]

The calcium silicate has the ability to interact with water leading to the setting and hardening of the cement. This is a hydration of the tricalcium silicate ($3\text{CaO}\cdot\text{SiO}_2 = \text{C}_3\text{S}$) which produces a hydrated calcium silicate gel (CSH gel) and calcium hydroxide ($\text{Ca}(\text{OH})_2$).

Clinical Application

1. Preservation of pulp vitality
2. Absence of post operative sensitivity: High biocompatibility
3. Prevention of dental failures Has excellent sealing properties
4. Ultimate dentine substitute

CONCLUSION

Biomimetic materials attempt to repair the damaged living tissue, using or promoting natural mechanisms of growth. This method provides remarkable possibilities well beyond the traditional mode of treatments in almost all fields of dentistry including preventive, restorative, periodontal and reconstructive surgery. It is hoped that further research will extend the potential of these biomimetic materials, although it is unlikely that there will ever be a single universal material.

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Comparison of Exercise and Non-Exercise Testing of Cardio Respiratory Fitness in Young Adults

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ABSTRACT

Cardio Respiratory Fitness (CRF) measures the cardiovascular and respiratory systems to perform physical activity. VO₂ max is the most accurate measure of cardio respiratory fitness and endurance. Routinely the VO₂ max can be estimated using exercise testing. It is not always feasible to use exercise testing hence; non-exercise test equations have been developed for the estimation of VO₂ max. The study aims to evaluate and compare the validity of non-exercise testing equations for Vo₂ max (developed for the western population) with exercise tests in young adults. Additionally, the study will explore Vo₂ max using Queen's college step test to find its association with BMI, physical activity level, gender, waist circumference and waist-hip ratio. A cross-sectional study on 96 participants was conducted. The participants performed a Queen's college step test. They also completed a physical activity rating scale to calculate non-exercise estimation of VO₂ max. The results show a significant correlation between various methods of VO₂ estimation. The results also show a significant correlation between VO₂ max calculated using Queen's step test with waist circumference ($p = .040$, $r = 0.210$), gender ($p = .000$, $r = .501$), activity ($p = .002$, $r = .310$) and waist-hip ratio ($p = .003$, $r = .304$). The non-exercise testing equation may be as accurate as the sub-maximal exercise test for estimation of VO₂ max. VO₂ max estimated through Queen's college step test is associated with gender, waist-hip ratio, and activity level.

Keywords: Cardio respiratory fitness, exercise testing equation, NET-F equation, non-exercise testing, VO₂ max, Queen's College Step Test





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INTRODUCTION

Cardiovascular disease is a leading cause of mortality and morbidity worldwide. The prevalence of cardiovascular disease (CVD) has increased substantially over the past few decades in the younger population.[1] Cardio Respiratory Fitness (CRF) is a fitness parameter that indicates the capacity of the cardiovascular and respiratory systems to perform physical activity. Youth with low cardiovascular fitness and high body fat have unfavorable cardiovascular risk profiles. Low Cardio Respiratory Fitness (CRF) is associated with a higher risk for mortality, which may be mediated by risk factors such as hypertension, diabetes, and hypercholesterolemia. Clinical studies have established a strong link between low CRF and various health conditions, including coronary artery diseases, high blood pressure, diabetes mellitus, and some cancers.[2] Therefore, estimating CRF is important as it can serve as an indicator of the risk for mortality. Increased CRF is often accompanied by favorable changes in other health indicators such as blood pressure, triglycerides, glycemic control, and body fat distribution.[3] Increased physical activity and fitness are associated with a reduction in the risk of cardiovascular disease, but the optimal intensity or amount of exercise necessary for reductions in risk or risk factors is unknown.[1] Therefore, there is a strong need for additional clinical measures and identifying huge risks in asymptomatic patients. Aerobic capacity, also known as VO₂ max, is the most accurate measure of cardiorespiratory fitness and endurance.[2] It is the maximum amount of oxygen used by the person during maximal or submaximal exercise and the value does not change despite an increase in workload over time. Higher oxygen consumption of an individual shows him/her a more efficient cardio-respiratory system. VO₂ max is expressed as liters/min as an absolute value or in milliliters /kg/min as relative VO₂ max. It depends on the genetic factors, body composition, age, sex as well as the ethnicity of an individual.[4]

The VO₂ max can be estimated using direct or indirect methods. Direct methods use instruments in the laboratory, while indirect methods rely on mathematical formulas. The use of a direct method (open-circuit spirometry in a laboratory) to measure VO₂ max is restricted because of its exhausting and difficult experimental protocol and the absence of a well-equipped laboratory. Several exercise-based methods indirectly calculate VO₂ max which takes into consideration a person's characteristics such as age, sex, anthropometric measurements, history of physical activity or resting level physiological measurements. Queen's College step test is one such method and is a submaximal exercise test. Stepping requires no elaborate or expensive equipment, no calibration, and can be easily administered to large numbers of people. [5] Estimating VO₂ max through exercise tests is difficult for large populations due to the need for costly equipment, space, and trained staff. It is also time-consuming and expensive. To overcome these challenges, non-exercise tests are recommended for calculating VO₂ max. Non-exercise predictive models estimate VO₂ max without exercise testing. The equations used for non-exercise testing are easy to apply, low-risk, cost-effective, and feasible. These equations can be performed in areas where infrastructure is limited because all the variables required for the estimation of non-exercise testing are either routinely available {gender, age, body mass index (BMI), resting heart rate (RHR)} or relatively easy to obtain (self-reported physical activity) in a primary care setting. Non-exercise testing estimating method has been shown to have good concurrent validity against exercise testing-estimated cardio respiratory fitness.[6] Evidence also suggests that non-exercise testing methods for estimating fitness (NET-F) equations are as accurate as some submaximal methods (Queen's College step test) to estimate CRF.

One of the studies among medical students evaluated the validity of the non-exercise test using the NASA/ Johnson Space Centre PA-R scale compared to exercise the protocol using the Queen's College step test. The study showed no statistically significant difference between VO₂ max obtained by both exercise and non-exercise protocols using the PA-R scale.[7] Cardio respiratory fitness is a known predictor of cardiovascular diseases (CVD), hypertension, and hyperlipidemia.[1] However, it is not usually assessed as part of individual risk assessment, possibly due to the practical difficulties of using a graded exercise test. To make CRF data more accessible, researchers have developed a range of Non-Exercise Estimated Cardio respiratory Fitness (NEECRF) equations for estimating CRF. NEECRF equations commonly include age, gender, resting heart rate, smoking status, BMI, and self-reported physical activity status (PAS). Studies have shown NEECRF equations to predict all cause and cardiovascular disease mortality on par with measured CRF.[8] Therefore, non-exercise testing methods for assessing cardio respiratory fitness have been





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developed. These methods provide a reasonably accurate estimation of CRF without the burden of exercise testing. The non-exercise testing equations have been developed for the Western population. However, it is unclear whether these equations are valid for the Indian population and whether cardiovascular disease risk factors (CRF) are routinely assessed in primary care settings, despite being a significant risk factor. Therefore, the present study aims to compare the estimation of VO₂ max by the non-exercise test with an exercise test to explore the validity of non-exercise test equations in the Indian population.

MATERIALS AND METHODS

The present study was a cross-sectional study conducted in the College of Physiotherapy at Pt. B.D. Sharma PGIMS, Rohtak. The ethical clearance was taken from the institutional biomedical research ethical committee of Pandit Bhagwat Dayal Sharma University of Health Sciences, Rohtak concerning the letter No. BREC/23/017. A signed written informed consent was taken from the participants. A simple random sampling method was used to collect the data. 96 participants aged between 18-25 years participated in this study. The study included both male and female adults. Individuals with a history of cardiac or lung disease, who were on regular medication use that affects the cardiovascular or respiratory system, and those undergoing any physical conditioning program were excluded from the study. The demographic details and self-structured form were completed by the participants. Data was collected regarding participant's height, weight, waist circumference, hip circumference, waist-hip circumference ratio, body mass index (BMI), resting heart rate (RHR), and physical activity level by using the questionnaire. Queen's college step test was used for VO₂ max estimation [2]. The exercise testing method used following equation:

(i) For male subjects: VO₂max (ml/kg/min) = 111.33 - (0.42 x pulse rate in beats per min)

(ii) For female subjects: VO₂max (ml/kg/min) = 65.81 - (0.1847 pulse rate in beats per min) [2]

Two equations for non-exercise testing were calculated. First NET-F equation

NET-F = [sex coefficient × 2.78 - (age × 0.11) - (BMI × 0.17) - (RHR × 0.05) + (physical-activity-level coefficient) + 21.41] [6].

The second equation used the NASA/Johnson Space Centre Physical Activity Rating (PA-R) scale. The equations for male and female subjects is as under:

Formale subjects: VO₂ max (ml/kg/min) = 67.350 – [0.381 x age (years)] – (0.754 x BMI) + (1.951 x PAR)

For female subjects: VO₂ max (ml/kg/min) = 56.363 – (0.381 x age (years) – (0.754 x BMI) + (1.951 x PAR). [7]

Statistical Analysis

Statistical analysis of data was performed using IBM SPSS. Independent t-test was used to compare mean waist and hip circumference, waist-hip ratio, QST, non-exercise testing equation, and NASA equation between males and females. Karl Pearson's coefficient of correlation was used to find out the correlation of the NASA equation with QST and NET-F.

RESULTS

Out of the 96 participants, the majority of participants were females 51 (53.1%) and 45 (46.9%) were males. Table 1 shows mean+SD values of age, BMI and VO₂ max estimation using three methods Table 2 shows a comparison of anthropometric measurements & VO₂max values using QST, NET, and NASA equations between males and females using an independent t-test. Male participants had significantly higher mean values for all the measures than female participants. Karl Pearson's coefficient of correlation was used to find the correlation between estimation using various methods/equation. The VO₂ max estimation using the NASA equation correlated moderately ($r=.588$, $P<0.01$) with VO₂ max estimation using the QST equation, and highly ($r=.838$, $p=.000$) with the NET equation. The results also show a significant and moderate correlation ($r=.560$, $p=.000$) between VO₂ max estimation through the NET equation with the Queen step test. Table 3 (here) Karl Pearson's coefficient of correlation was also used to study the association of VO₂max estimated by Queen's college step test with various demographic factors. The results show a weak significant correlation between QST and Waist circumference ($p = .040$, $r=0.210$) and a highly significant correlation





between QST and gender ($p = .000$, $r = .501$). A moderately significant correlation was found between QST with activity ($p = .002$, $r = .310$) and waist hip ratio ($p = .003$, $r = .304$).

DISCUSSIONS

The present study aimed to compare the exercise and non-exercise testing methods of cardiorespiratory fitness in young adults. The male and female participants differed significantly in BMI, waist circumference and waist-hip ratio. This difference in anthropometric evaluation may be due to inherent physiological differences in body composition and fat deposition. The mean value of the Queen's college step test (39.10 ± 6.38) is comparable to a study done by Narkhede et al. (2014) in which the mean value of the Queen's College Step Test (QST) was 39.91 ± 4.02 . Estimation of VO_2 max by non-exercise testing revealed that the mean value of VO_2 max by using a non-exercise testing equation was in line with the study of Shenoy et al (2012) in which the mean value of VO_2 max by using a non-exercise testing equation was 43.25 ± 7.81 . [9] Estimation of VO_2 max by NASA/Johnson Space Centre physical activity rating scale revealed that the mean value of VO_2 max by using non-exercise testing is consistent with the mean value of VO_2 max calculated by Jang et al. (2012) which was 44.27 ± 7.37 . [10] The results of the present study revealed that there was a significant correlation between exercise testing and non-exercise testing of VO_2 max (** $P < 0.01$). The results of the study are consistent with the study done by Rao et al (2019). [2] Thus, non-exercise protocols are accurate in estimating VO_2 max because they are time and resource-efficient, and may be used for individuals of any age and with any cardiorespiratory disease. They could be especially beneficial for assessing fitness in children and the elderly, who may be unable to comply with exercise guidelines.

The association of VO_2 max estimated by Queen's college step was also studied with various demographic and anthropometric variables. VO_2 max was not significantly correlated with age ($p = .280$), which is contrary to the findings of Varghese et al. (2018). [11] This may be due to the narrow range of age group i.e 18-25 years. The results of the present study show a significant association of QST with gender which is consistent with the findings by Varghese et al.(2018) and Buttar et al. (2020). [11][12] This may be due to discrepancies attributed to physiological variation. Gender is one of the measure determinants of VO_2 max. The factors that influence higher aerobic capacity in males are post-pubertal hormonal-induced higher lean body mass and HB content. [13] Also, females due to smaller body size have small cardiac size or blood volume. Lower hemoglobin in females is associated with reduced blood viscosity resulting in a proportionate increase in blood flow and cardiac output. [14] The waist-hip ratio exhibited a negative association with QST ($r = -.304$). The findings of the present study imply that the human body influences cardiorespiratory fitness. In obese people, there is an increase in type-II muscle fiber and a decrease in type-I muscle fiber, which may contribute to lower oxygen absorption. Obesity in general is connected with decreased physical fitness and an increased risk of cardiovascular disease. There was a significant correlation between QST with activity level ($r = .310$) which is consistent with the study done by Sardar et al. (2008). [15] This might be attributed to physical activity activating the cardiovascular system, resulting in an adaptation that improves oxygen transport and contributes to an increase in VO_2 max.

CONCLUSION

The study found that males had significantly higher VO_2 max as compared to females. The VO_2 max estimation by three methods significantly correlated with each other which suggests that the non-exercise testing equation may be as accurate as the submaximal exercise test. VO_2 max estimation using Queen's college step test was significantly associated with gender, waist-hip ratio and activity level of the participants.

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Conflicts of Interest: No conflicts of interest**Ethical approval**

The ethical clearance was taken from the Institutional Biomedical Research Ethical Committee of Pandit Bhagwat Dayal Sharma, University of Health Sciences, Rohtak, concerning letter No. BREC/23/017 on 16 Jan 2023.

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Natural, Synthetic and Semi - Synthetic Polymers As Building Blocks of Modern Pharmaceutics

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ABSTRACT

Natural polymers are stemmed from renewable sources such as plants, animals and microorganisms ex: cellulose, starch. Natural polymers are favoured for their biocompatibility and sustainability .They often serves as thickeners and binders. Synthetic polymers are made-made materials created through chemical synthesis. Synthetic polymers offer precise control over properties such as viscosity, solubility and film formation. Semi- synthetic polymers are stemmed from natural sources but are chemically modified to improve their properties or functionally ex: Carboxy methyl cellulose and semi synthetic polymers offer a balance between natural and synthetic options. They provide enhanced stability in cosmetics. Identify suitable natural polymers based on desired properties and functionality ex: Thickening. conduct compatibility tests with other formulation ingredients to ensure stability and efficacy. Select appropriate semi-synthetic ex: cellulose based on their modified properties and assess compatibility and interactions with other formulation components through screening experiments. Choose synthetic polymers ex:” polyvinyl alcohol based on desired functionalities and properties.

Keywords: Natural polymers, Semi-synthetic, Synthetic polymers, Cosmetic formulation, Carrageenan, Xanthum gum, Hydroxyethyl cellulose

INTRODUCTION

The personal care and cosmetics sectors have seen tremendous growth in the twenty-first century. Over the course of the forecast period (2016–2022), the global cosmetics market is expected to increase at a compound yearly growth rate of 4.3%, reaching \$429.8 billion by 2022.[1] Cosmetics are defined by the European Commission (2015) as any material or preparation that is meant to come into touch with the teeth, oral cavity mucous membranes, hair system,





nails, and different exterior aspects of the human body.[2] In fact, polymers can be found in a variety of hair care products, including shampoos, conditioners, hair dyes, fixing gels, and tip repair; in skincare goods, including lotions, liquid soaps, sunscreens, and corporate oils; and in nail care, cosmetics, and scent products.[3] Each of these products has unique uses and applications, as well as variations in composition, production techniques, and physical and chemical factors that necessitate a wide range of polymers. Polymers are a significant category of raw materials used in cosmetic formulations since they are necessary for the creation of high-performing goods. They can be categorised as natural, semi-synthetic, or synthetic macromolecules because they are made up of several repeating units, or monomers, which are often grouped in a chain. Within the formulations of cosmetics, its structural variety is employed as rheology modifiers, thickeners, foam stabilisers and destabilizers, emulsifiers, fixatives, conditioning agents, and film formers to support a range of purposes.[3-5]

Polymers

Being vital to the creation of high-performance goods, polymers constitute a significant class of raw ingredients used in cosmetic formulations. Depending on how many repeating units (monomers) they contain and how they are structured, they can be categorized as synthetic, semi-synthetic, or natural macromolecules. Its structural variety is utilized to support a range of functions in cosmetic formulations, including conditioning, foam formers, emulsifiers, thickeners, foam stabilizers and destabilizers, rheology modifiers, and fusions. Natural, semi-synthetic, and synthetic polymers' characteristics and applications in cosmetic formulations are covered in this review (Figure 1).[3, 5]

Polymers in cosmetic formulation

Polymers are frequently found in many cosmetic and personal care products. They belong to a single class of materials that have a variety of characteristics similar to the class of polymers that have been used. The class of polymers covered in this section has been applied to several fields. The properties of various polymers types are displayed for use in cosmetic formulations.

Synthetic polymers

The fact that synthetic polymers can be customized for particular uses makes them appealing as an excipient in cosmetic formulations. They can be made uniformly on a big scale, are long-lasting, and frequently cost less than natural polymers. Acrylic acid-based polymers, polyacrylamides, silicon, and alkylene oxide-based homopolymers and copolymers are the synthetic polymers most frequently encountered in cosmetics.[6] In recent times, the cosmetics sector has employed silicon materials. Biomethane and cyclomethycaine are two examples of composites made of silicon that are utilized as suspending agents and in processes like emulsification and associative thickening in cosmetics like deodorants, shampoos, and antiperspirants.[7] Analogs of polyethylene glycols (PEGs), whether they are non-ionic or anionic, are frequently found in cosmetics as emollients (which aid in lubricating and softening the skin), emulsifiers (which aid in the proper mixing of water- and oil-based products), and penetration enhancers (which aid in the delivery of other compounds deeper into the skin). They can be found in deodorant, shampoo, hair conditioners, bath and shaving products, skin care products, makeup, and skin cleansing goods.[8] *Mangifera indica* L. kernel extract was used in Poomanee et al. (2020)'s development of nano emulsion loadings to improve the extract's stability and skin penetration, making it a potentially effective anti-acne treatment.[9] Safflower oil served as the oil phase in the mixture, which also included sorbitan, PEG-7 glyceryl cocoate, cetareth-20, and PEG-40 hydrogenated castor oil as surfactants. Butylated hydroxytoluene and oleate together. *M. indica* kernel extract's physicochemical, antibacterial, and skin permeability were demonstrated by the production of a nano emulsion with extremely small droplet sizes and a restricted distribution. The good features of biodegradability, biocompatibility, and mass producibility are possessed by aliphatic polyesters, like poly (lactic acid) (PLA), poly (ϵ caprolactone) (PCL), and poly (3-hydroxybutyrate-co-3 hydroxy valerate). Natural polymers (such cellulose, chitin, and gelatine) do not have the exceptional mechanical qualities or melting processability that these materials possess. Aliphatic polyesters are being considered for the creation of microbeads for environmentally friendly cosmetics because of their qualities[9] according to Table 1.



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With distinct physicochemical and mechanical properties, cellulose derivatives can be broadly classified into two groups: cellulose esters and cellulose ethers. Characteristics of cellulose derivatives include stability against biodegradation, heat, hydrolysis, and oxidation, surface activity, viscosity in solution, and thermoplastic film qualities. As opposed to cellulose esters (cellulose acetate, cellulose acetate phthalate, cellulose acetate butyrate, cellulose acetate trimellitate, hydroxypropyl methylcellulose phthalate), which are soluble in water, cellulose ethers (e.g., methylcellulose, ethyl cellulose, hydroxyethyl cellulose, hydroxypropyl methylcellulose, carboxymethyl cellulose, and sodium carboxymethyl cellulose) are soluble in water. have high film-forming properties but are often water-insoluble polymers.[15] In cosmetics such as creams, shampoos, lotions, and gels, these polymers are primarily utilized as thickening, stabilizing, gelling, and bioadhesive agents. Natural gelling substances such as starches, acacia, sodium alginate, agar, pectin, and gelatine are more resistant to microbial infection.[7] Using synthetic, semi-synthetic, natural, or a combination of polymers, Aung et al. (2019) created dissolving microneedles to facilitate trans epidermal distribution of alpha-arbutin for skin lightening.[16] The patch was made with GantrezTM S-97, hydroxypropyl methylcellulose, polyvinylpyrrolidone K-90, and chitosan as the polymers. I.e. The most appropriate polymer combination to create alpha-arbutin-loaded dissolving microneedles, according to their observations, is 8% w/w HPMC:40% w/w PVP K-90 (1:1). This is because alpha-arbutin has greater mechanical strength and penetration than gel formulation.

Natural polymers

As seen in Figure 2, natural polymers have mostly been employed in cosmetic applications. They may be used for a wide range of purposes, such as skin and hair care, makeup, and as stabilisers and modifiers. They are also biocompatible, safe, environmentally friendly, and very marketable to consumers.[18,19] Polysaccharides, starch, xanthan gum, guar gum, carrageenan, alginate, pectin, gelatine, agar, collagen, and hyaluronic acid are among the most widely utilised natural polymers. Polysaccharides called starches are found in nature and may be utilised in two different ways as soluble and granule starch. After being heated during extraction, the soluble starch dries and becomes resistant to damp, leaving skin and hair feeling silky. The hydrogen bonds in the granule starch are altered, making it unbreakable, which leads to Because of their varying amylase concentrations, the diverse sources of starch, such as non-ionic polymers like potato, maize, pinion,[20] and cassava root, each provide the cosmetic compositions somewhat varied qualities. Starch and other natural polymers, such as chitosan, have been combined to provide antioxidative release and other skin-related properties.[21] In cosmetic applications, such as lotions and nail lacquers, chitosan is frequently used alone. Examples of these applications include hair and skin care.. Another well-known feature of chitosan is its antibacterial capabilities[22-24], and is thus utilized in a variety of deodorants, particularly because the solution is still sprayable. In addition to being utilized as a stabilizer in a variety of formulations,[25-28] chitosan enhances the adherence of fragrances to skin.[29] Furthermore, acne can be treated using chitosan.[30] Chitosan's treatment are what give it its moisturising properties. [31, 32] Additionally, chitosan has been employed as a carrier for many medicinal items. For example, dental plaque was reduced by 70% and bacterial counts were reduced by 85% dental plaque was contained in chitosan gels containing herbal extracts. Spray-drying chitosan was used to create sodium fluoride-containing microparticles that may be used by fluoride-controlled delivery devices to act as a fluoride reservoir in the oral cavity. Dental varnishes with antibacterial efficacy against S. mutations and the capacity to prevent demineralization were created using nanoparticles of chitosan as a fluoride-controlled delivery system carrier was validated. [33, 34] Another naturally occurring polymer is cellulose, which requires chemical changes such substitution processes to be employed in cosmetic applications because it is insoluble in water. After being chemically altered, cellulose fibrils produce skin care products that are non-irritating, have good skin adhesion and spreadability, and are perfect for usage as face masks.[35] Additionally, several cosmetic formulas are thickened using ionic cellulose polymers to boost their viscosity and stability.

Advantages' and disadvantages of polymers used in cosmetic formulation**Applications of polymers in cosmetic formulations**

The application of polymers in the restoration of many materials, including metals, wood, and ceramics, has grown dramatically in recent years. This is because polymers have advantages over traditional materials, such as easy



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processing, increased productivity, and decreased value.[49] Cosmetic goods' viscosity and flow properties can be changed with the use of polymers. In goods with water and oil phases, polymers function as stabilisers and emulsifiers. Polymer/layered silicate (PLS) nano-composites have garnered significant attention in recent times, from academia and industry alike, due to their notable ability to improve material properties when compared to traditional micro and macro composites or virgin polymer. Certain polymers form films on the skin or hair, giving makeup longevity benefits. High moduli, enhanced heat and strength resistance, reduced flammability and gas permeability, as well as enhanced biodegradable polymers are a few examples of these enhancements. However, there has been a lot of interest in theory and simulations that deal with the synthesis and characteristics of such materials, as well as the fact that they are thought to be special model systems for examining the dynamics and structure of polymers in small spaces.

CONCLUSION

For the treatment of skin, teeth, hair, and nails, various physicochemical and biological properties of polymers and other modified derivative polymers can be used. They also possess the ideal attributes to support active chemicals found in cosmetics. Because these crucial characteristics are frequently associated, determining which characteristics are more relevant for a particular application requires a precise polymer characterisation. Because polymers have so many applications, it is important to characterize them not just in terms of their physical-chemical properties but also in terms of their functional attributes, environmental and biological safety, and biopharmaceutical activity.

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Table 1: Properties of polymers

Polymers	Properties	Ref
PEG, PPG	Humectant and surface activity	[7]
Dimethicone	Thermoreversible hydrogels that provide protection, emollience, and improved comfort	[10]





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Poloxamer	Boost body temperature viscosity and non-ionic surfactant	[11]
Poly (lactic acid)	Microbeads for exfoliation, a biodegradable substitute	[12]
Poly caprolactone)	Polymers not biodegradable, forming of films, elastic properties Shape memory impacts	[13]
Polyurethanes	Water resistance, gloss, and feel of the surface	[14]
Polyquaternium	Antistatic, conditioning, and film-forming	[7]

Table 2: Properties of semi-synthetic polymers

Polymer	Properties	Ref
Nitrocellulose	Develop a film, Wear products longer, and improve skin	[17]
Acrylate – copolymers	Enhanced product appearance and safety	[7]
Hydroxyethyl cellulose	Improved product shelf life, rheological control, and simplicity of use	[7]

Table 3: Properties of natural polymers

Polymers	Properties	Ref
Starch	Emulsifying agent , Film forming, High viscosity and Lip care	[36]
Chitosan	Long-term colour adhesion, hydration, antibacterial qualities, and film formation	[37]
Cellulose	gives hair a moisturized, silky, and anti-static finish	[38]
Sericin	Increases elasticity and has a large capacity to take up moisture.	[39,40]

Table 4: Advantages’ and disadvantages of polymers

Polymers	Advantages	Disadvantages	Ref
Natural	Enhancer of water solubility Reduced or non-toxic Excellent transparency and edema Both biodegradable and biocompatible able to combine with medications Easily accessible minimal immunogenicity Passivity	Heavy metal and microbiological pollution Uncontrolled pace of hydration variance from batch to batch Slow production pace arduous extraction process	[41-43]
Synthetic	Simple customization enhanced chemical and mechanical stability Increased Reproducibility Varying Selectivity and Specificity Simple to break down suitable for clinical settings	Inherent biocompatibility and bioactivity deficiencies Potential to induce immunological reaction, inflammation, and toxicity synthesis process that is costly and difficult Problems with water solubility	[44-47]
Semi-synthetic	Sustainability and renewable energy sources Degradability and biocompatibility customized property Effects on the environment	Cost Differentiation in the original content processing complexity limited toughness Regulation-related difficulties	48





	Adjustability	
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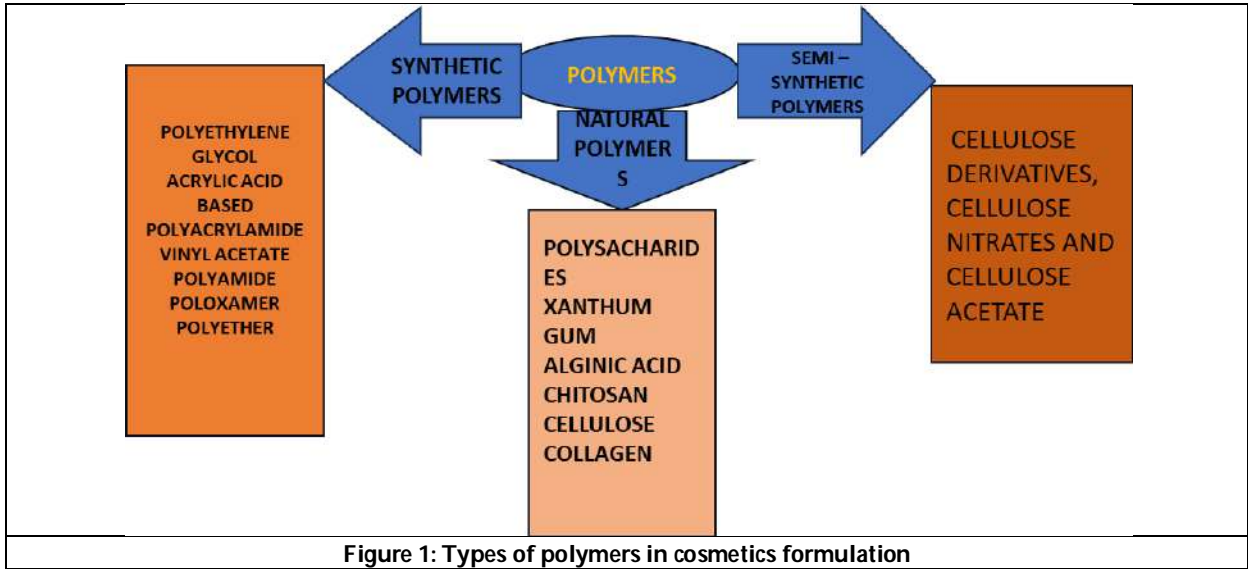


Figure 1: Types of polymers in cosmetics formulation





Sustainable Business Innovation-Rethinking of Business Models for Long-Term Success

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ABSTRACT

The rapidly evolving global landscape is compelling businesses to rethink their traditional models in favour of sustainable business innovations. This paper explores the shift towards Sustainable Business Innovation (SBI), focusing on how firms are altering their strategies to align with environmental, social, and governance (ESG) goals for long-term success. By analyzing key drivers, challenges, and examples of businesses embracing sustainability, the paper demonstrates how incorporating sustainability into core business practices enhances resilience and competitiveness. The study also highlights strategic frameworks and methodologies guiding this transition, emphasizing the importance of circular economy principles and stakeholder collaboration.

Keywords: Sustainable Business Innovation, Circular Economy, ESG Goals, Stakeholder Collaboration

INTRODUCTION

In today's fast-evolving global environment, business firms are facing unique challenges driven by environmental degradation, resource scarcity, and shifting consumer preferences. The traditional business models that once guaranteed success are increasingly becoming obsolete encountering these challenges. As the world contends with the issues of climate change, ecological imbalances, and social inequalities, companies are under pressure to not only deliver financial performance but also to operate in a socially and environmentally responsible way. This has led to the rise of Sustainable Business Innovation, where businesses are rethinking their models and operations to ensure long-term success while positively impacting society and the environment. Sustainable business innovation involves designing and implementing new strategies that prioritize environmental sustainability, social equity, and economic viability. The objective is to embed sustainability within their strategies and initiatives into the very core of a business



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model, from supply chain operations to product design and customer engagement. Unlike traditional models that aimed at short-term gains, sustainable business models aim for long-term value generation for stakeholders—customers, employees, investors, communities, and the planet. Business firm's that adopt these models are not only more resilient in the face of market disruptions but are also positioned to attract socially conscious consumers and investors who increasingly demand corporate responsibility. The need for sustainable business innovation is further reinforced by global sustainability initiatives, like the United Nations' Sustainable Development Goals (SDGs) and the Paris Agreement on climate action, which urge businesses to take action towards creating a sustainable future. Additionally, technological advancements in areas like clean energy, circular economy models, and digital transformation provide new and different avenues for businesses to innovate to reduce environmental footprint while enhancing profitability. This research article sight sees how companies can rethink their business models through the lens of sustainability to achieve long-term success. It delves into the key drivers behind the shift towards sustainable innovation, the challenges companies face in this transition, and real-world examples of organizations that have effectively incorporated sustainable business practices. The paper also examines the strategic frameworks and methodologies that guide sustainable business innovation, throwing newer insights into how businesses can build a competitive edge while making a positive contribution to global sustainability.

Business Models: An Introduction

A business model is the blueprint through which an organization creates, delivers, and captures value, both for itself and its stakeholders. It defines how a company generates revenue, structures its operations, and engages with its customers. Business models are essential to the survival and success of any enterprise, guiding decision-making and operations in a way that aligns with long-term strategic goals. Essentially, they encompass every aspect of a company's structure, from its products or services to its marketing, distribution, and cost management strategies. Over time, business models have evolved in response to changing technologies, consumer behavior, and economic conditions. Traditional business models, which were dominant before the digital age and sustainability-driven transformations, were primarily profit-oriented and focused on efficiency and mass production. However, these models are being intensely scrutinized for their long-term sustainability in a world facing environmental degradation, resource depletion, and evolving consumer demands.

Traditional Business Models and Their Characteristics

Traditional business models have resulted in commercial success, emphasizing profitability and growth through standard market practices, including mass production, linear supply chains, and economies of scale. These models are precisely developed to prioritize short-term financial gains, driven by cost reduction and efficiency without significant regard for environmental or social impacts (Bocken et al., 2014). The value proposition in traditional models centers on delivering quality products or services to consumers, usually at competitive prices, while maximizing shareholder value. Traditional business models follow a linear, "take-make-dispose" production and consumption framework, where natural resources are sourced, turned into goods, sold, and eventually discarded. This method is embedded in sectors like manufacturing, agriculture, and energy production, allowing businesses to expand quickly by meeting consumer demand. However, the focus on profit maximization often overlooks environmental sustainability and social equity (Yang et al., 2017). Traditional business models refer to the conventional ways' businesses operated before the rapid technological advancements and global sustainability movement. These models were largely centered on profit maximization, mass production, and efficiency through economies of scale. They often involved predictable supply chains, established markets, and relatively static customer bases. Traditional models focused on delivering physical goods or services in an environment with less competition from digital-first enterprises.

Some key characteristics of traditional business models include

1. Profit-Centric Focus: The primary goal of traditional models was maximizing profit margins by leveraging cost efficiencies, often at the expense of environmental or social concerns.



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2. **Linear Supply Chains:** Traditional models typically follow a linear process from raw material extraction to product creation, distribution, and eventual disposal. This model emphasizes a "take, make, dispose" approach, without considering resource regeneration.
3. **Customer Acquisition and Loyalty:** Traditional models emphasized customer loyalty programs and advertising to acquire and retain customers, primarily through physical stores or direct sales.
4. **Centralized Operations:** These models often featured centralized decision-making, with a top-down approach that was slow to adapt to market changes or customer demands. Innovation was typically incremental rather than disruptive.
5. **Labor-Intensive Processes:** Many traditional models relied heavily on manual labor and large workforces, particularly in sectors like manufacturing, agriculture, and retail.

Negative Impact of Traditional Business Models

While traditional business models have driven global economic growth, they have led to a range of harmful impacts on both the environment and society. The linear model, based on the excessive extraction of natural resources, has led to the depletion of finite resources and significant environmental degradation (Schaltegger et al., 2016). For instance, industries that rely heavily on fossil fuels have highly contributed to carbon emissions, exacerbating climate change and causing irreversible damage to ecosystems. The mass production of goods also results in vast amounts of waste, with products and packaging ending up in landfills or polluting oceans, creating significant ecological imbalances (Bocken et al., 2014). Traditional business models have also been criticized for fostering inequality and social injustice. Companies in pursuit of cost reductions frequently exploit workers in developing nations, resulting in low wages, poor working conditions and child labour. This pursuit of profit at the expense of human welfare has created ethical concerns for consumers and regulators alike (Yang et al., 2017). Additionally, traditional business models often lack transparency, which can lead to corporate scandals, such as environmental violations and the exploitation of marginalized communities. While traditional business models were profitable for decades, they are increasingly seen as unsustainable and harmful in today's evolving market landscape. The negative impacts include:

1. **Environmental Degradation:** Traditional business models, particularly those relying on mass production and resource extraction, have significantly contributed to environmental issues such as pollution, resource depletion, and climate change. The linear "take, make, dispose" approach leads to excessive waste and carbon emissions, which are unsustainable in the long term.
2. **Inflexibility and Resistance to Change:** Traditional models are often slow to adapt to technological advancements or changes in consumer preferences. This can make businesses vulnerable to disruption by more agile competitors who adopt innovative, digital, or sustainable practices. Many companies have struggled to pivot their models, leading to declining market share.
3. **Short-term Profit Focus:** Many traditional models focus prioritizing short-term profits often comes at the cost of long-term sustainability. This leads to underinvestment in areas like innovation, employee well-being, and corporate social responsibility.
4. **Social Inequality:** Traditional business models have promoted exploitative labour practices, especially in global supply chains. Low wages, poor working conditions, and the outsourcing of labour to developing countries are all consequences of models that prioritize cost-cutting and profit over social responsibility.
5. **Depletion of Resources:** Companies relying on finite, non-renewable materials are facing high pressure as these resources become scarcer. The long-term viability of businesses dependent on such resources is under threat, especially as regulatory and consumer demands shift toward more sustainable practices. While traditional business models have historically driven economic growth and profitability, they are no longer suitable for the challenges of the modern world. As environmental sustainability and technological advancements take center stage, companies must reinvent their business models, moving towards innovation and long-term success. Transitioning to sustainable models is not merely for survival but creates opportunities for enduring value for businesses, society, and the planet.





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RESEARCH METHODOLOGY

This research employed a qualitative approach using a systematic review of research articles related to business models and sustainability, case studies of companies that have transitioned to sustainable business models were reviewed. Secondary data from industry reports, academic journals was analysed to identify common strategies, challenges, and success factors. Additionally, thematic review was followed to uncover insights into the role of ESG factors in business model innovation. This methodology allows for a comprehensive exploration of sustainable business innovation and its impact on long-term business success.

Sustainability in Business Models

In today's business scenario, sustainability has become a critical component of long-term success. Sustainability in business means operating in ways that are economically practical, socially responsible, and environmentally friendly. It goes beyond profit generation to address the broader impacts of business operations on society and the planet. The objective of fulfilling sustainability in business models has grown due to increasing awareness of climate change, environmental degradation, resource depletion, and social inequalities. Consumers, investors, and governments are now demanding greater accountability from companies, urging them to prioritize sustainable practices that protect the environment and support communities. Sustainability offers several advantages for businesses, including improved brand image, increased consumer loyalty, and reduced operational costs through energy efficiency and waste reduction. Moreover, sustainable businesses are able to mitigate risks related to regulatory changes, market shifts, and resource scarcity.

The Need to Move from Traditional Business Models to Sustainable Business Models

Given the negative impacts of traditional business models, the need to gravitate towards sustainable models has become critical. Sustainable business models integrate environmental, social, and governance (ESG) factors into their core strategies, promoting long-term value creation that benefits society and the planet (Evans et al., 2017). Sustainability in business is not just driven by the need to meet statutory requirements but also by increasing consumer preferences towards ethically produced and environmentally responsible products. Businesses fail to meet these shifting consumer demands risk losing market position and tarnishing their public image (Schaltegger et al., 2016). Sustainable business models focus on circularity, where resources are reused, recycled, and regenerated to minimize waste and reduce dependence on finite resources. This shift from a linear to a circular economy allows businesses to become conscious of their environmental footprint while creating economic opportunities (Bocken et al., 2014). Furthermore, sustainable business models emphasize social equity by ensuring fair labor practices, community engagement, and ethical supply chains. Traditional business models, while profitable for decades, are increasingly seen as inadequate for delivering to the challenges of the 21st century. These models, often characterized by mass production, linear supply chains, and a focus on short-term profit, have contributed to environmental harm, social inequality, and economic instability. The linear "take, make, dispose" approach of traditional models has resulted in massive waste production, resource depletion, and high carbon emissions, exacerbating environmental issues such as climate change and biodiversity loss. Moreover, traditional business models prioritize profit maximization at the expense of long-term sustainability. This short-sighted focus can lead to poor working conditions, exploitative labour practices, and the depletion of resources, all of which undermine the long-term existence of businesses. Companies that fail to adopt sustainable practices risk losing consumer trust, facing regulatory penalties, and falling behind competitors who have embraced more responsible business models. In contrast, sustainable business models prioritize long-term value creation by embedding environmental, social, and governance (ESG) factors into their core operations. These models emphasize resource efficiency, renewable energy adoption, circular economy principles (which aim to reduce waste and recycle resources), and ethical labour practices. By adopting sustainable business models, companies can reduce their environmental footprint, support social progress, and secure their economic future. The global shift toward sustainability is further driven by global efforts such as the United Nations' Sustainable Development Goals (SDGs) and the Paris Agreement on climate initiatives. These frameworks urge businesses to adopt ways that contribute to global sustainability.



**Stephen Deepak and Shanthi****The Paradigm Shift in Developing a Sustainable Business Model**

The transition from traditional to sustainable business models represents a significant paradigm shift. This shift requires businesses to rethink their value propositions, operations, and relationships with stakeholders. The development of sustainable business models are not about tweaking existing practices but about fundamentally transforming the way businesses operate. Companies must move from a linear to a circular economy model, where products are designed for durability, reuse, and recycling, and waste is minimized throughout the supply chain. One of the prominent pointer of this paradigm shift is the integration of corporate social responsibility (CSR) and environmental stewardship into the core business strategy, rather than treating these as peripheral concerns. Businesses are now recognizing that sustainability can be a driver of innovation, opening up new markets, products, and services that cater to environmentally conscious consumers. For instance, the advances in green technologies, renewable energy solutions, and sustainable packaging are all a result of businesses embracing sustainability as a core value. Another critical factor in developing sustainable business models is collaboration with stakeholders. Businesses must work closely with governments, non-governmental organizations (NGOs), consumers, and communities to create systems that benefit all parties involved. This collaborative approach ensures that businesses not only meet regulatory requirements but also address the needs and concerns of the wider society. Lastly, emerging technologies like artificial intelligence, big data analytics, and the Internet of Things (IoT) are helping businesses refine their processes, aligning with sustainability goals by reimagining the core aspects of value creation, delivery, and capture. Sustainability is no longer a niche concern but a fundamental aspect of modern business strategy. As the world faces pressing environmental and social challenges, companies must move away from traditional business models that prioritize short-term gains and adopt sustainable practices that ensure long-term success. This paradigm shift requires businesses to innovate, collaborate, and leverage technology to create models that benefit the environment, society, and the economy. Sustainable business models are not just the future of business—they are essential for the survival and prosperity of companies in the 21st century.

Sustainable Business Model Innovation: A New Framework

Sustainable business model innovation (SBMI) requires a fundamental rethinking of how businesses operate. Companies must redesign their value propositions to offer products and services that address sustainability challenges while meeting consumer needs. SBMI involves developing new technologies, processes, and practices that minimize environmental harm, promote resource efficiency, and support social well-being (Evans et al., 2017). For example, companies can adopt renewable energy sources, improve energy efficiency, and design products with sustainability in mind, such as using recyclable materials or reducing packaging waste. Furthermore, collaboration with stakeholders, including suppliers, consumers, and governments, is essential to developing sustainable business models that are scalable and impactful (Yang et al., 2017). The transition to SBMI also involves financial innovation, such as incorporating the true cost of resources, emissions, and waste into pricing strategies, ensuring that the business's economic activities contribute to environmental and social sustainability. This shift not only reduces the risk of regulatory penalties but also opens new markets and business opportunities (Schaltegger et al., 2016). Sustainable business model innovation (SBMI) has emerged as a critical framework for integrating environmental and social sustainability into the core of a business. Rosaria Ferlito and Rosario Faraci's research article, "Business Model Innovation for Sustainability: A New Framework," offers valuable pointers into how businesses can adapt their models to fulfil the demands of sustainability by rethinking three key components: value proposition, value creation and delivery, and value capture.

Value Proposition

The value proposition in SBMI refers to the sustainable benefits offered to customers and other stakeholders (Ferlito & Faraci, 2023). It goes beyond merely delivering products or services; it involves offering solutions that positively impact society and the environment. Companies aiming for SBMI must realign their objectives to focus on creating shared value for customers, communities, and ecosystems. Sustainable value propositions are often centered around reducing waste, minimizing environmental footprints, and promoting fair labour practices. For instance, firms in the circular economy provide customers with products designed for reuse and recycling, thereby reducing the utilization of resources and fostering environmental stewardship (Ferlito & Faraci, 2023).





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Value Creation and Delivery

Value creation and delivery in sustainable business models require innovation in operational processes and supply chains to ensure that business activities are environmentally and socially responsible. According to Ferlito and Faraci (2023), sustainable value creation demands a shift from traditional linear processes to circular systems. Businesses must innovate by adopting clean technologies, using renewable energy, and ensuring resource efficiency throughout the production and delivery process. Additionally, value creation should engage stakeholders, including customers, suppliers, and communities, to ensure that sustainability objectives align with broader societal goals. Collaboration and transparency across the value chain are essential for ensuring long-term sustainability and stakeholder trust.

Value Capture

Value capture in the context of SBMI involves rethinking how businesses generate revenue while ensuring sustainable outcomes (Ferlito & Faraci, 2023). Traditional models focused solely on profit maximization often ignore environmental and social costs. In contrast, sustainable models prioritize long-term value for all stakeholders by incorporating the true costs of resources, waste, and emissions into their financial strategies. This could involve adopting pricing mechanisms that reflect the full environmental cost of products or implementing shared value models where companies reinvest part of their profits into social and environmental initiatives

Model of Sustainable Business innovation

Sustainable Business Models

As businesses worldwide face increasing pressure to address environmental and social concerns, several sustainable business models have emerged, allowing companies to align their operations with sustainability goals while maintaining profitability. Here are five popular sustainable business models that offer long-term benefits for both businesses and society:

Circular Economy Model

The circular economy model is based on minimizing waste and maximizing the reuse of resources. Unlike the traditional linear model of "take-make-dispose," the circular economy emphasizes closing the loop by recycling, reusing, and regenerating materials. This model promotes the making of products are dismantled and reassembled, allowing for the reuse of components. Companies like Patagonia and IKEA have adopted this model by offering repair services and recycling programs, reducing the utilization of virgin materials while extending product life cycles (Bocken et al., 2016).

Product-as-a-Service Model

This model shifts the focus from selling products to providing services. Instead of customers owning the products, they pay for the utility or service the product offers. This approach incentivizes companies to create durable, long-lasting products since ownership remains with the business. For example, Rolls-Royce uses a "Power by the Hour" model, where customers pay for the engine's performance rather than purchasing the engine outright. This model reduces waste, ensures efficient use of resources, and fosters long-term customer relationships (Lacy & Rutqvist, 2015).

Social Enterprise Model

A social enterprise is a business that prioritizes solving social or environmental issues over maximizing profits. These organizations aim to create positive change by reinvesting their profits into causes that benefit society. TOMS Shoes, for instance, operates on a "buy one, give one" model, where every pair of shoes sold helps provide shoes to children in need. Social enterprises contribute to sustainable development by addressing issues such as poverty, health, and education, ensuring that business growth is aligned with social welfare (Alter, 2007).

Inclusive Business Model

Inclusive businesses integrate low-income populations into their value chain as suppliers, distributors, or customers. These businesses create opportunities for marginalized communities by providing access to jobs, goods, and services



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that improve their standard of living. Companies like Grameen Bank and Unilever's Project Shakti have successfully employed this model by offering microfinance and empowering rural women to distribute products in underserved areas. This model fosters economic growth while reducing inequality (Pralhad & Hart, 2002).

B Corp Certification Model

B Corp Certification is awarded to companies that achieve rigorous standards in social and environmental performance, accountability, and openness. Ben & Jerry's and The Body Shop are examples of businesses that have obtained B Corp certification, ensuring that their operations benefit people and the planet. B Corporations are legally obligated to consider how their decisions affect all stakeholders, including workers, communities, and the environment. This model encourages ethical practices, long-term sustainability, and corporate responsibility (Honeyman, 2014).

CONCLUSION AND DISCUSSION

Sustainable business innovation marks a fundamental shift from traditional, profit-driven models to ones prioritizing long-term environmental, social, and economic benefits. This shift is crucial as businesses face increasing pressure from consumers, investors, and regulators to adopt more responsible practices. Our analysis reveals that companies integrating sustainability into their operations are better positioned to remain competitive, resilient, and compliant with global initiatives like the SDGs. However, the transition is not without challenges, particularly in balancing profitability with sustainability goals. Despite these hurdles, they offer a roadmap for enduring success, providing value to all stakeholders while addressing the urgent challenges of resource depletion and environmental degradation.

Industry and Managerial Implications

For industries, adopting sustainable business innovations presents opportunities to create value beyond profitability, such as brand enhancement, operational efficiency, and risk mitigation. Managers must foster a culture of sustainability by embedding environmental and social considerations into every aspect of decision-making. This includes rethinking supply chains, adopting circular economy principles, and fostering collaboration across sectors. Moreover, businesses that prioritize sustainability will be better equipped to attract socially conscious consumers and investors, adapt to regulatory pressures, and navigate market disruptions. For long-term success, leaders must champion sustainability as a core business strategy, leveraging innovation and stakeholder engagement to drive meaningful change.

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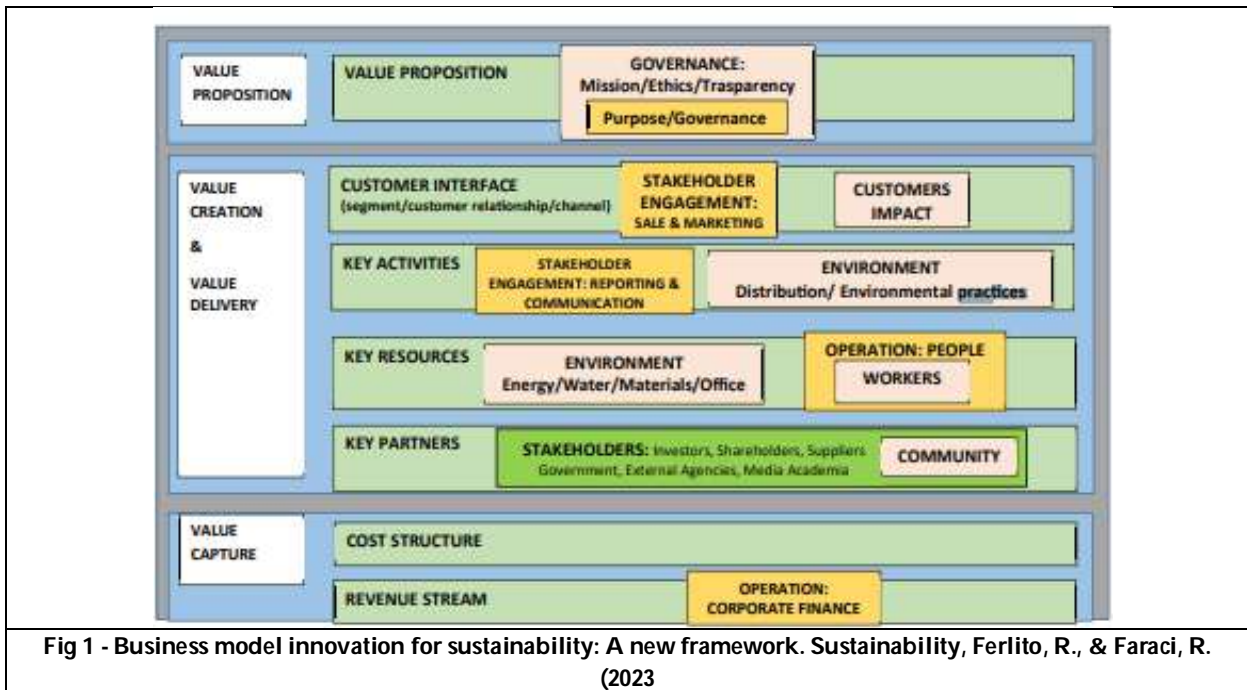


Fig 1 - Business model innovation for sustainability: A new framework. Sustainability, Ferlito, R., & Faraci, R. (2023)





Catalyzing Micro-Entrepreneurship: An Analysis of Mudra Loan Disbursement among Indian States

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ABSTRACT

This study examines the effectiveness of the MUDRA scheme in bridging the finance gap for micro-enterprises in India. Focusing on five key states - Tamil Nadu, Karnataka, Uttar Pradesh, West Bengal, and Maharashtra - and three PMMY categories, the analysis reveals trends in loan disbursements and participation of women entrepreneurs. With over 5.77 crore micro-units seeking high-cost funds outside the formal credit system (NSSO, 2013), MUDRA's impact is crucial. This research provides valuable insights to inform policy decisions and optimize the scheme's effectiveness in supporting micro-entrepreneurs.

Keywords: MUDRA Loan, State-wise comparison, Loan Disbursement, Women entrepreneurs.

INTRODUCTION

Pradhan Mantri MUDRA Yojana (PMMY), launched in 2015, bridges the credit gap for small and micro enterprises. It provides loans up to INR 10 lakh through banks, NBFCs, and MFIs, categorized into Shishu, Kishore, and Tarun based on the business life cycle. In 8 years, PMMY has disbursed INR 22.89 lakh crore to 41.16 crore loan accounts, benefiting weaker sections. The Tarun category's loan limit has been increased to INR 20 lakh, effective from Budget 2024, however this is not reflected in this paper.



**Jayaraksana et al.,****Objectives**

The study objectives are to analyze MUDRA loan trends across India (2015-2023), examine state-wise disbursement trends in the top 5 states (Tamil Nadu, Karnataka, Uttar Pradesh, West Bengal, and Maharashtra), and assess the components benefiting women Entrepreneurs.

SCOPE AND RESEARCH METHODOLOGY

This study analyses PMMY's performance (2015-23) in the top 5 states, loan categories, and women's participation using secondary data from official reports. Statistical tools (mean, standard deviation, coefficient of variation) analyze loan disbursement trends, state performance, and women's participation.

DATA ANALYSIS AND INTERPRETATION

Objective 1: Analyze trends in MUDRA loan disbursements in India (2015-2023)

Pradhan Mantri Mudra Yojana disbursements grew consistently from ₹ 100,000 crores in 2015-16 to nearly ₹ 500,000 crores in 2022-23. Growth doubled by 2018-19, stabilized during COVID-19 (2019-20), and then accelerated post-pandemic, demonstrating Mudra's increasing support for small businesses and economic growth.

Objective 2: Study MUDRA loan trends in TN, Karnataka, UP, WB, and Maharashtra.

PMMY promotes financial inclusion and top-performing states are TN (₹ 231,185), KA (₹ 214,215.43), UP (₹ 210,652.44), WB (₹ 196,374.89), and MH (₹ 191,897), leading in MUDRA loan disbursement and accounting for a significant share of total disbursements.

MUDRA LOAN DISBURSAL TRENDS: TOP 5 STATES**Stability and Financial Support**

Maharashtra and Karnataka are most stable, while Tamil Nadu is moderately stable. West Bengal and Uttar Pradesh are the least stable due to high variability. Tamil Nadu provides the highest financial support, whereas Maharashtra offers the lowest. Uttar Pradesh and West Bengal's support variability affects their stability.

STATE-WISE INTERPRETATION**1) TAMIL NADU**

Tamil Nadu's MUDRA loans (2015-23): SISHU (₹ 14,500.87) was the most stable (CV: 26.89%), KISHORE (₹ 9,377.28) most variable (CV: 57.83%). 2019-2022 saw a shift from SISHU to KISHORE indicating a change in micro-enterprise support trends.

2) KARNATAKA

KA's A/Cs & Disbursement Trends over the years (Rs in crores) Karnataka's MUDRA loans: SISHU (₹ 10,925.55) was most stable (CV: 18.52%), KISHORE (₹ 10,234.19) most variable (CV: 43.50%). 2019-2020 saw a shift from SISHU to KISHORE/TARUN, indicating changed funding priorities.

3) UTTAR PRADESH

UP's A/Cs & Disbursement Trends over the years (Rs in crores)

Uttar Pradesh's MUDRA loans: SISHU (₹ 10,460.39) was fairly consistent (CV: 31.98%), KISHORE (₹ 9,216.86) highly variable (CV: 49.48%), and TARUN (₹ 6,654.30) moderately variable (CV: 41.46%). SISHU surged, dipped, and rebounded; KISHORE grew steadily; and TARUN fluctuated before stabilizing.

4) WEST BENGAL

West Bengal's MUDRA loans: SHISHU (₹ 11,299.66, CV: 31.88%) was most stable, KISHORE (₹ 9,789.93, CV: 68.10%) highly variable, and TARUN (₹ 3,457.27, CV: 50.32%) moderately consistent. SHISHU supported small enterprises steadily, while KISHORE fluctuated and TARUN needed stability.





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5) MAHARASHTRA

Maharashtra's MUDRA loans: SISHU (• 9,030.86, CV: 21.62%) was most consistent, TARUN (• 6,918.77, CV: 27.20%) moderately variable, and KISHORE (• 8,037.49, CV: 38.14%) highly variable. Post-pandemic, Maharashtra witnessed a remarkable recovery, fueling a "start-up resurgence".

Objective 3: Evaluate MUDRA's components benefiting women.

MUDRA loans empower women entrepreneurs, driving economic growth and social change. With 65% of beneficiaries being women, more than 35 million have started businesses, becoming self-reliant and contributing to India's socio-economic progress. MUDRA loan allocation to women has shifted significantly. Initially, SHISHU dominated, but its share decreased. KISHORE (growth phase) rose from 13.70% to 42% by 2022-23, while TARUN (mature businesses) also increased. This shift prioritizes supporting women entrepreneurs in growth stages, aligning with efforts to strengthen women's Entrepreneurship.

KEY FINDINGS OF THE STUDY

- Karnataka, Maharashtra, and Tamil Nadu top Shishu loan disbursements, ensuring constant funding for new micro-enterprises.
- Maharashtra's Tarun loans demonstrate steady growth, with the lowest CV.
- The States saw a rise in Kishore loans despite the pandemic, highlighting the ongoing financial needs of existing micro-enterprises
- Shishu loans (up to • 50,000) have consistently grown, benefiting first-time entrepreneurs, driving financial inclusion, and contributing most to Mudra's success.
- Top MUDRA disbursers in FY 2022-23: UP (• 47,427 cr), TN (• 43,730 cr), Karnataka (• 40,746 cr). TN's consistency outshone UP and Maharashtra's volatility.
- TN's higher MUDRA disbursements than Maharashtra, suggest allocation imbalances.
- Most states saw rising Shishu loans in 2019-2020, except TN and Karnataka, where micro-enterprises shifted to larger Kishore/Tarun loans.
- FY 2020-2021 saw a sharp decline in MUDRA loans, especially the Shishu category, due to COVID-19, as NBFCs and SFBs reduced lending.
- Women entrepreneurs received 47.74% of total MUDRA loans.
- Women's MUDRA loan allocation shifted from Shishu to Kishore and Tarun, indicating reduced early-stage dependence and increased support for growing and mature businesses.

CONCLUSION

The MUDRA scheme has made significant strides in fostering micro-enterprise growth and financial inclusion, particularly in states like Tamil Nadu, Karnataka, Uttar Pradesh, West Bengal, and Maharashtra. However, disparities in disbursement highlight the need for more equitable fund distribution across regions. The pandemic-induced decline in Shishu loans underscores the vulnerability of new enterprises and the necessity for crisis-resilient support systems. After an impressive eight-year journey, the scheme has demonstrated its vital role in "funding the unfunded". To enhance its impact, it is crucial to ensure balanced resource allocation, strengthen financial safety nets, and focus on supporting the transition from Shishu to Kishore and Tarun loans, especially for women entrepreneurs. To further strengthen the MUDRA scheme, developing tailored support strategies for different categories of loans will be crucial in ensuring more inclusive and sustainable growth for micro-enterprises across India.

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Table 1: Overall disbursal trend of PMMY in India

Duration	Amount Disbursed (in Rs. crores)
2015-16	132954.73
2016-17	175312.13
2017-18	246437.4
2018-19	311811.38
2019-20	329684.63
2020-21	311754.47
2021-22	331432.595
2022-23	450423.655

Source: <https://financialservices.gov.in/>

Table 2: Disbursal trends among 5 states over the years (Rs in crores)

YEARS	TAMILNADU	KARNATAKA	UTTAR PRADESH	WEST BENGAL	MAHARASTRA
	Disbursal Amt	Disbursal Amt	Disbursal Amt	Disbursal Amt	Disbursal Amt
2015-16	15496.86	16469.43	11880.93	7740.41	13372.42
2016-17	17756.39	17290.7	14753.59	15480.03	16976.76
2017-18	24980.92	22500.67	21174.46	19970.76	22266.2
2018-19	33807.87	29345.44	24888.92	25892.29	25741.99
2019-20	34615.11	29702.91	29801.37	26457.87	27394.57
2020-21	28534.56	29785.29	27875.13	28529.86	24624.06
2021-22	32262.94	28374.92	32850.8	33949.81	25416.48
2022-23	43730.39	40746.09	47427.26	38353.86	36104.52

SOURCE: <https://www.mudra.org.in/>

Table 3

	TAMIL NADU	KARNATAKA	UTTAR PRADESH	WEST BENGAL	MAHARASTRA
Std Dev	8712.895726	7385.960932	10449.27166	9259.994647	6410.430939
Mean	28898.13	26776.93125	26331.5575	24546.86125	23987.125
CV	30.15037902	27.58329871	39.68345458	37.72374216	26.72446548





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Table 4: TN's A/Cs & Disbursement Trends over the years(Rs in crores)

TOTAL No.of.ACCOUNTS AND AMOUNT DISBURSED OVER THE YEARS IN TAMIL NADU																
CATEGORY	2015-2016		2016-2017		2017-2018		2018-2019		2019-2020		2020-2021		2021-2022		2022-2023	
	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED
SISHU	4506237	8231.68	5000285	10897.54	5366167	13237.23	6528577	18597.62	6401813	21205.44	4150574	13455.17	4667349	16613.04	3906300	13769.27
KISHORE	234824	4282.07	275564	4258.53	431666	7176.1	601720	8710.56	574390	7771.78	721372	9789.17	894274	10467.36	2416492	22562.67
TARUN	40506	2983.11	34008	2600.32	62332	4567.59	310365	6499.7	141463	5637.89	75786	5290.21	63523	5182.54	83721	7398.44

Table 5: KA's A/Cs & Disbursement Trends over the years(Rs in crores)

TOTAL No.of.ACCOUNTS AND AMOUNT DISBURSED OVER THE YEARS IN KARNATAKA																
CATEGORY	2015-2016		2016-2017		2017-2018		2018-2019		2019-2020		2020-2021		2021-2022		2022-2023	
	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED
SISHU	4153714	9071.71	3546071	8166.92	4065431	10351.83	4913740	13428.73	4738282	14017.62	3466071	9998.03	3312243	9676.81	3846632	12692.75
KISHORE	264744	4744.94	332182	5402.85	434785	7177.23	722789	9764.81	861216	9850.88	1091077	12878.14	898314	12768.9	1652609	19285.78
TARUN	41151	2652.78	55325	3720.93	68277	4971.61	170407	6151.9	133629	5834.4	88048	6909.13	87924	5929.2	92825	8767.55

Table 6: UP's A/Cs & Disbursement Trends over the years(Rs in crores)

TOTAL No.of.ACCOUNTS AND AMOUNT DISBURSED OVER THE YEARS IN UTTAR PRADESH																
CATEGORY	2015-2016		2016-2017		2017-2018		2018-2019		2019-2020		2020-2021		2021-2022		2022-2023	
	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED
SISHU	3149078	5849.68	3076798	6756.77	3963399	8396.56	4441760	9954.05	5222319	13802.3	3898753	10016.97	4592780	12615.74	5042608	16291.05
KISHORE	160502	3325.18	213841	4388.28	362732	7171.13	445656	8318.56	542245	8806.14	737244	10461.37	1098459	12523.61	1629124	18740.63
TARUN	35802	2706.07	46908	3608.53	75086	5606.77	88545	6616.31	96858	7192.93	102455	7396.79	96743	7711.45	136989	12395.57

Table 7: WB's A/Cs & Disbursement Trends over the years (Rs in crores)

TOTAL No.of.ACCOUNTS DISBURSED OVER THE YEARS IN WEST BENGAL																
CATEGORY	2015-2016		2016-2017		2017-2018		2018-2019		2019-2020		2020-2021		2021-2022		2022-2023	
	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED
SHISHU	2487603	4086.8	4415268	10912.17	4497279	11909.15	5000300	14441.19	5719479	17357.48	4145668	9323.34	3872638	10555.12	3648648	11812.03
KISHORE	118927	2201.84	125457	2576.24	436208	5555.31	745479	8208.19	413590	5824.68	1251084	15636.53	1692375	19313.74	1675422	19002.89
TARUN	22018	1451.77	25780	1991.62	33799	2506.3	110269	3242.91	43460	3275.71	54168	3569.99	62218	4080.95	102846	7538.94

Table8: MH's A/Cs & Disbursement Trends over the years(Rs in crores)

TOTAL No.of.ACCOUNTS AND AMOUNT DISBURSED OVER THE YEARS IN MAHARASTRA																
CATEGORY	2015-2016		2016-2017		2017-2018		2018-2019		2019-2020		2020-2021		2021-2022		2022-2023	
	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED	No.of.A/Cs	AMT DISBURSED
SISHU	3337382	6616.11	3054130	6909.4	3145685	7980.26	3750570	10052.07	4131535	12110.75	2912303	7665.66	3306200	9312.02	3856944	11600.63
KISHORE	154441	3461.97	220662	4947.01	354818	7343.4	510249	8287.28	505154	7268.66	736733	9565.76	756828	9048.63	1268689	14377.2
TARUN	43242	3294.34	69362	5120.34	96117	6942.55	125162	7402.64	133199	8015.16	105127	7392.64	95024	7055.82	127691	10126.69





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Table 9: Overall Distribution of MUDRA Loans to Women by Category (%)

Categorical Distribution of MUDRA Loans to Women (%)			
	SHISHU (%)	KISHORE (%)	THARUN (%)
2015-16	80.10%	13.70%	6.20%
2016-17	84.60%	11.20%	4.20%
2017-18	78.90%	15.70%	5.40%
2018-19	72.80%	19.87%	7.36%
2019-20	76.50%	17.60%	5.90%
2020-21	57.55%	38.02%	4.43%
2021-22	54.28%	41.75%	3.98%
2022-23	52.24%	42.67%	5.17%

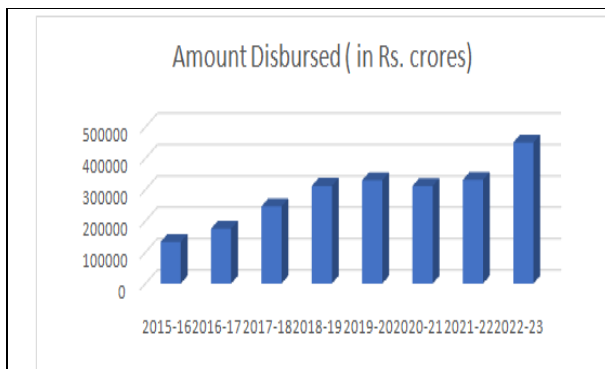


Figure 1: Overall Disbursal trend of PMMY in India

Source: <https://www.mudra.org.in/>

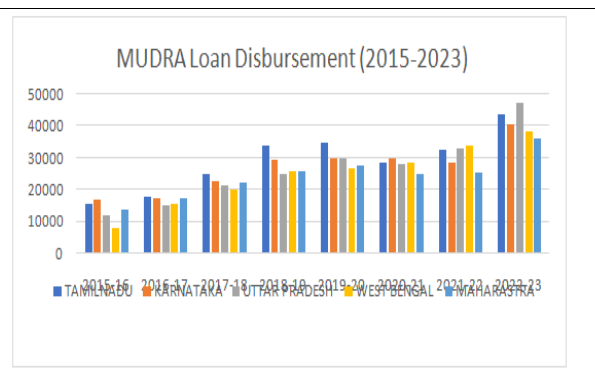


Figure 2: Trends in disbursal among five states over the years Source: <https://www.mudra.org.in/>

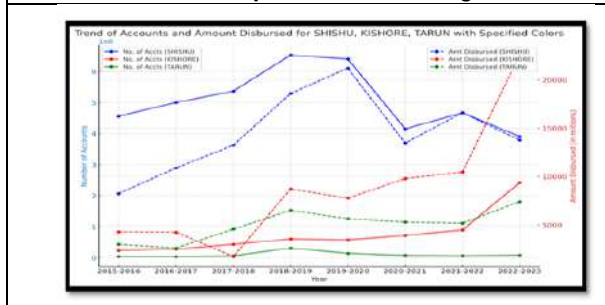


Figure 3: TN's A/Cs & Disbursement Trends over the years(Rs in crores) Source: <https://www.mudra.org.in/>

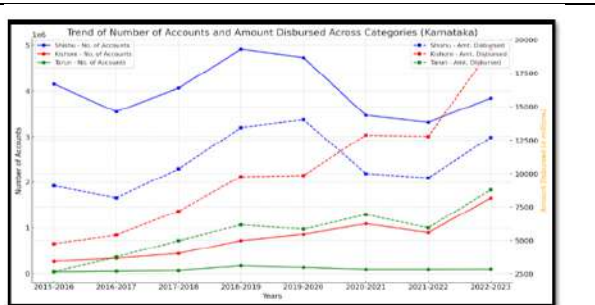


Figure 4: KA's A/Cs & Disbursement Trends over the years(Rs in crores) Source: <https://www.mudra.org.in/>





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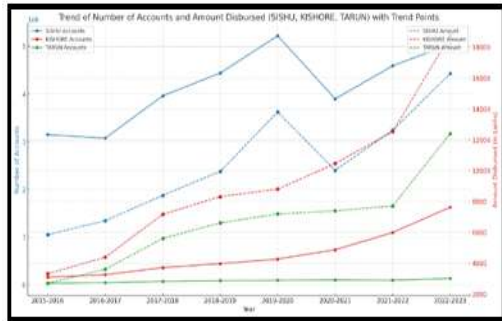


Figure 5: UP's A/Cs & Disbursement Trends over the years (Rs in crores) Source: <https://www.mudra.org.in/>

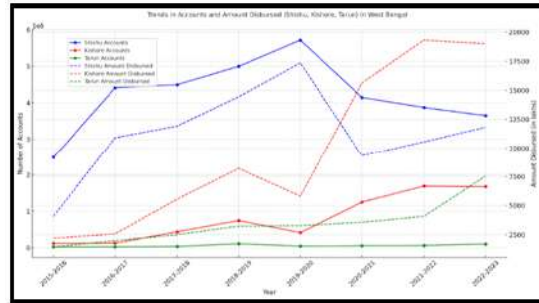


Figure 6: WB's A/Cs & Disbursement Trends over the years (Rs in crores) Source: <https://www.mudra.org.in/>

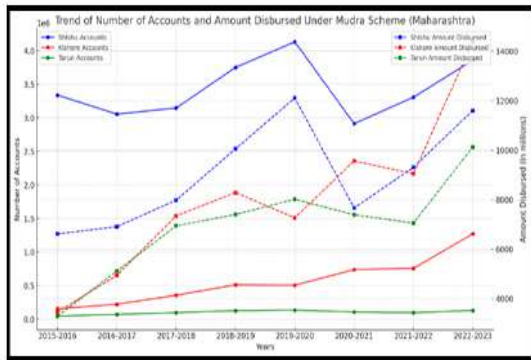


Figure 7: MH's A/Cs & Disbursement Trends over the years (Rs in crores) Source: <https://www.mudra.org.in/>

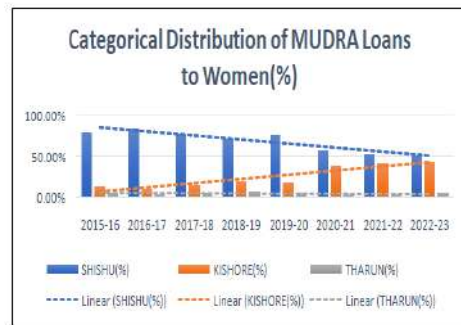


Fig. 8: Overall Distribution of MUDRA Loans to Women by Category (%) Source: <https://www.mudra.org.in/>





A Study on Attitude of Business Women: Growth and Competitiveness in Madurai District

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ABSTRACT

This study explores the attitudes of sampled business women in Madurai district towards growth and competitiveness. It aims to understand the factors influencing their entrepreneurial journeys, the challenges they encounter, and their perspectives on the business environment. Through in-depth interviews and surveys, the study collected data from a diverse group of women entrepreneurs operating in various sectors. The findings reveal that while women entrepreneurs in Madurai district are driven by a strong desire to attain financial freedom and contribute to their society. They have also faced significant problems that can hinder their growth. The problems namely lack of capital, societal and cultural barriers, lack of support networks, work-life balance struggles, and policy limitations. Despite these obstacles, many women entrepreneurs demonstrate resilience, adaptability, and a willingness to take risks. In order to address these problems and to improve the development of women entrepreneurs in Madurai district, it is recommended for several policy interventions by the government and NGOs. These include improving access to finance, enhancing support systems, promoting gender equality, and addressing work-life balance issues. This paper is focused to review and study the problems faced by women entrepreneur and to provide suitable solutions and policy recommendations to the government to empower the women entrepreneur in the study area.

Keywords: Entrepreneurship, Growth, Competitiveness, entrepreneur and Empowerment.



**Dilipan and Theenathayalan****INTRODUCTION**

In India for centuries, male entrepreneurs has been dominating predominantly in business, manufacturing and others. Whereas the women involvement in business is not up to the mark. However, in the recent past it observed that a growing emphasis on women's potential to contribute significantly to the nation's economic growth. Indian administrators and policymakers must devise innovative methods to inculcate entrepreneurial skills among women. Indian women entrepreneurs are having a very long history of challenging gender stereotypes, excelling in various fields traditionally dominated by men. From their roles as warriors and rulers to their current achievements in the corporate world, women have consistently demonstrated their capabilities and managerial prowess. Renowned for their attention to detail, dedication, and empathy, women possess qualities essential for successful entrepreneurship. These traits, often observed in their management of household affairs, belie the misconception that they are ill-suited for leadership roles. Indian women have proven to be excellent managers, capable of planning, budgeting, and executing strategies effectively in both personal life and professional life.

Growth of Women Entrepreneurs

In recent years, the entrepreneurial landscape of Madurai district has witnessed a notable surge in the number of women-owned businesses. This is because of several factors, including increased access to education, government initiatives supporting women entrepreneurs, and changing societal attitudes. Education has played a significant role in empowering women in Madurai district to pursue entrepreneurial ventures. With higher levels of education, women have gained the knowledge, skills, and confidence to explore business opportunities. Government initiatives such as self-help groups, microfinance schemes, and skill development programs have also provided essential support to aspiring women entrepreneurs. These initiatives have helped women access capital, acquire necessary skills, and build networks within the business community. Moreover, societal attitudes towards women's entrepreneurship have evolved positively. Traditional gender roles are gradually changing, and women are increasingly encouraged to pursue their career aspirations. This shift in mindset has created a more supportive environment for women entrepreneurs, allowing them to overcome societal barriers and pursue their business goals. Despite these positive developments, women entrepreneurs in Madurai district still face several challenges that can hinder their growth. One of the primary obstacles is access to capital. Obtaining loans and funding for business ventures can be difficult for women entrepreneurs, especially those from marginalized communities. Limited access to financial resources can restrict their ability to expand their businesses, hire employees, and invest in new technologies. Another challenge is the work-life balance struggle. Balancing the demands of running a business with family responsibilities can be particularly challenging for women. Societal expectations and cultural norms often place a disproportionate burden of domestic work and professional work on women. Furthermore, women entrepreneurs may face discrimination and gender bias in the business world. They may encounter challenges in networking, securing contracts, and accessing mentorship opportunities. It is suggested to implement the targeted policies and initiatives for women empowerment through local, state and central governments.

- Improved access to finance: Providing easier access to loans and funding for women-owned businesses through microfinance schemes, government grants, and venture capital funds.
- Enhanced support systems: Establishing mentorship programs, business incubation centers, and networking opportunities specifically designed for women entrepreneurs.
- Skill development and training: Offering targeted capacity building programs to equip women entrepreneurs with fundamental and necessary skills along with computer literacy to succeed in their businesses.
- Policy reforms: Implementing policies that promote gender equality and address discriminatory practices in the business world.
- Awareness campaigns: Raising awareness about the contributions of women entrepreneurs and challenging gender stereotypes.





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By providing the basic needs and good governance the women entrepreneurs will move forward to take up new business ventures in Madurai district. There by women entrepreneurs contribute to the society in terms of employment and income generation in the study area.

Objectives

- To evaluate the growth trajectory and future prospects of women entrepreneurs in establishing businesses in Madurai district.
- To identify the problems faced by the women entrepreneurs in the Madurai District.

METHODOLOGY

An interview schedule was used to collect primary data from the women entrepreneurs in the study area relating to the prospects and problems. In order to collect data and information convenience method was applied. A sample of 50 respondents have been identified from the study area for collection of primary data. Secondary data was also used where ever necessary.

Tools of Analysis

The Garret value and scores of each rank is used in this study.

$$\text{Per cent position} = \frac{100 (R_{ij} - 0.5)}{N_j}$$

R_{ij} = Rank given for the i th variable by the j th respondent.

N_j = Number of variables ranked by the j th respondent.

RESULTS AND DISCUSSION

The entrepreneurial landscape of Madurai district has witnessed a burgeoning number of women-owned businesses in recent years. This growth is a testament to the increasing number of women who are breaking down traditional gender stereotypes and pursuing their entrepreneurial aspirations. However, despite the progress made, women entrepreneurs in Madurai district continue to face peculiar problems that that can impact their attitudes towards growth and competitiveness. This study aims to explore the attitudes of sampled business women in Madurai district towards growth and competitiveness. By understanding their perspectives, we can gain valuable insights into the factors influencing their entrepreneurial journeys and the challenges they encounter. This knowledge can inform policy decisions and support initiatives aimed at empowering women entrepreneurs and robust a more inclusive, balanced and sustainable business environment.

Prospects of Women Entrepreneurs to establish Business

The entrepreneurial landscape of Madurai district has witnessed a steady increase in the number of women-owned businesses in recent years. However, despite this growth, women entrepreneurs in the region continue to face multiple challenges that can delay their success the business. This study aims to explore the prospects of women entrepreneurs to establish businesses in Madurai district, considering the various issues that influence their entrepreneurial growth. By understanding these challenges and opportunities, we can develop targeted strategies to support women entrepreneurs and foster a more inclusive business environment. From table 1, it is revealed that all the five reasons are equally important for becoming an entrepreneur. The reason for becoming on entrepreneur the respondents favoured mostly in terms of financial improvement, risk taking / decision making followed by independent. It is observed that the data is based on a survey of a relatively small sample size (50 respondents) and may not be representative of the entire population of women entrepreneurs. It is observed that Personality Development / Skill utilization ranked placed as number I followed by Independent, Risk taking / Decision making, Social reorganization / standard of living and Financial Improvement. It is important to note that the table only





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shows ranking based on the Garret ranking system. There may be other ranking system that order these factors differently.

Problems of Women Entrepreneurs

It has been identified and listed 16 problems faced by the women entrepreneurs in Madurai district. These challenges are multifaceted, stemming from societal, cultural, economic, and policy-related factors. From the table it is understood that problems faced by the women Entrepreneurs. Among all the problems financial problem and competition among / within the business communities are the major problems followed by family life balance, decision making, labour management, net working challenges and lack of confidence. The other problems are manageable problems expressed by the respondents in the study area.

CONCLUSION

Women entrepreneurship is the backbone of economic growth and development of any region. It is a multifaceted profession that is basically interesting, creative and enterprising. For centuries entrepreneurship has historically been a male-dominated one. But today women entrepreneurs plays a crucial role in business, manufacturing and MEMEs. The performance of women entrepreneurs seems to be remarkable and inspiring in Madurai district. Women's economic contribution through self-employment and industrial initiatives start up as increased attention from the NGOs and Government organizations. It is important to note that the problems and challenges faced by the women entrepreneurs in Madurai district can be reduced through policy changes and provision of loan without security along with subsidy and low rate of interest.

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Table 1 : Reasons for Becoming Women Entrepreneurs

Particular	I	II	III	IV	V	Total
1.Social Reorganization \standard of living	8	6	5	11	20	50
2.Financial Improvement	6	11	12	15	3	50
3.Personality Development\ Skill utilization	11	15	10	7	8	50
4. Risk taking\ Decision Making	14	8	20	3	7	50
5. Independent	11	10	3	14	12	50
Total	50	50	50	50	50	50

Source: primary data





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Table 2 : Percent Position

SI. No	Percent position	Calculate Value	Garret Value
1	100(1-0.5) 5	10	75
2	100(2-0.5) 5	30	60
3	100(3-0.5) 5	50	50
4	100(4-0.5) 5	70	39
5	100(5-0.5) 5	90	24

Source: primary data

Table 3 : Source of Prospects of Women Entrepreneurs- Garret Score

Particular	I	II	III	IV	V	Total
1	600	360	250	429	480	2119
2	450	660	600	195	72	1977
3	825	900	500	273	192	2690
4	1050	480	1000	117	168	2815
5	825	600	150	546	288	2409

Source: primary data

Table 4 : Factor Influencing for Becoming for Women Entrepreneurs- GARRET Ranking

SI. No.	Source of Women Entrepreneurs	Total score	Average	Rank
1	Social Reorganization \standard of living	2119	42.38	IV
2	Financial Improvement	1977	39.54	V
3	Personality Development\ Skill utilization	2690	53.8	I
4	Risk taking\ Decision Making	2815	43.7	III
5	Independent	2409	48.18	II

Source: primary data

Table 5: Problems of Women Entrepreneurs

SI. No.	Problems of women entrepreneur	Yes	No
1	Financial	47	3
2	Travel	8	42
3	Communication	5	45
4	Labour Management	13	37
5	Decision Making	17	33
6	Family life Balance	23	27
7	Supply	12	38
8	Gender	6	44
9	Mental Barriers	12	38
10	Education and Managerial skill	6	44
11	Network challenges	10	40
12	Competition	42	8
13	Lack of confidence	10	40





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14	Social culture barriers	9	41
15	Role of confidence	9	41
16	Low mobility	6	4





Determinants of MSME Growth in a Developing Region: a Case Study of Madurai District, Tamil Nadu

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ABSTRACT

This study investigates in the factor influence the development of MSMEs in Madurai district, a developing region in India. By employing a mixed-methods approach, combining quantitative and qualitative research techniques, we explore the determinants of MSME growth in this context. **Access to Finance:** MSMEs in Madurai district face significant challenges in obtaining adequate financing, hindering their growth potential. **Infrastructure Development:** The availability of quality infrastructure, including transportation and communication facilities of MSME growth. **Government Policies:** Supportive government policies, such as tax incentives, subsidies, and credit facilities, can significantly boost MSME growth. **Innovation and Technology:** MSMEs that adopt innovative practices and technologies are more likely to achieve higher growth rates. **Human Capital:** The availability of skilled labor and entrepreneurial talent is essential for MSME development. **Market Access:** Access to domestic and international markets is a serious factor in determining MSME growth. Policymakers should focus on improving access to finance, enhancing infrastructure development, implementing supportive government policies, fostering innovation, investing in human capital development, facilitating market access and MSME growth and contribute to the overall economic growth of the region.

Keywords: MSMEs, Entrepreneurs, Growth, Development and Finance.





INTRODUCTION

In the MSMEs cooperate a pivotal task in the financial growth of developing regions, providing employment opportunities, fostering innovation, and contributing to the overall growth of the local economy. It influence MSME growth entrepreneurs skills identical. This study delves into the determinants of MSME growth in Madurai district, a representative district in the developing Indian state of Tamil Nadu. Madurai district, with its rich historical and cultural heritage, has witnessed a significant expansion of its MSME sector in recent years. However, the growth trajectory of MSMEs in this region are complex interplay of factors, including economic, social, and institutional variables. By examining these determinants, the research will employ a mixed-methods qualitative and quantitative research techniques and analysis of survey data collected from MSMEs in Madurai district, exploring the relationship between various factors and MSME growth. Qualitative research will involve in-depth interviews with MSME owners, policymakers, and industry experts and the challenges and opportunities of business sectors.

REVIEW OF LITERATURE

Asghar, Nawaser, Paghaleh and Khaksar (2011) evaluated the government policies with respect to the MSMEs and the performance of these enterprises in relation to these policies and assistance and also concentrate on entrepreneurship within the Micro, Small and Medium-sized enterprises addition, they also consider the contribution of MSMEs towards country's employment generation. Liji Jolly in his article on "Globally, micro, small, and medium-sized enterprises (MSMEs) are acknowledged as a crucial component of national economies, making a substantial contribution to the growth of employment and the reduction of poverty. This includes government policies and tiny sectors in India. Acknowledging the significance of micro and small businesses, which constitute a significant portion of the Indian economy the role in employment, exports, industrial production, and an entrepreneurial foundation Development and promotion for modern era describes as "the most employment-intensive segment".

OBJECTIVE

To analyze the growth rates of MSME factors influencing Madurai district.

METHODOLOGY

An analytical one and comprises of both the primary information and secondary records and publications and documents such as annual reports, census reports, small Industries Service Institute (Now MSMEs Development Institute). District Industries Centre, District Statistical Office and various Statistical Handbooks, journals like Asian Research Consortium, Indian Journal of Agricultural Economics and International Journal of Management Research and Business Strategy, Magazines like Economics and School of Management Studies, CUSAT books like organization and Management of Small-Scale Industries, Himalaya Publishing Home in Micro Enterprises and periodicals. The economics of MSME in Madurai district, 100 respondents were selected by adopting the proportionate probability random sampling method. The factors (i) Cell phone and accessories shops, (ii) Stationary and Xerox shops, (iii) Bakery and sweets Shops (iv) Furniture shops, (v) Sales and service of Motor cycles shops and (vi) Miscellaneous and which included all other enterprises. The following tools are multiple regression formula models are used in the study as follows:

$\text{Log } y = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \dots + \beta_{10} \log X_{10} + u$, where

Y = Total growth scale value for ten components (in Nos.)

X1 = Initial capital

X2 = Fixed investment, Rs. in lakhs X3 = Owned fund, Rs. in lakhs

X4 = Borrowed capital, Rs. in lakhs X5 = Working capital

X6 = Term loans

X7 = Employment generation X8 = Value of products



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X9 =Sales turnover

X10 =Net profit

$\beta_0 \beta_1 \dots \beta_{10}$ are the parameters to be estimated.

RESULTS AND DISCUSSIONS

It measured the quantity the increase of MSMEs with the assist of a scale built with the aid by the research. In the examined, ten additives have been diagnosed to measure the growth of MSMEs and they shape the basic of measurement. All the 10 additives are accountable both partially or completely for the 100 boom of the MSMEs. In this table 1 shows the level of growth value of MSMEs. As shown in Table 1, the coefficients of difference are 9.91 percent for high-level growth, 7.06 percent for medium-level growth, and 12.52 percent for low-level growth. It is inferred that MSMEs with medium-level growth are more consistent in those with high-level growth. In the calculated outcomes of growth rate of MSMEs in table 2. It is inferred that the table 2 that the co-efficient of R^2 value into 0.5315 indicating 53.15 consistent with cent variant in increase of MSMEs degree of freedom. It step with cent boom in those 4 variables may want to growth boom scale with the aid of 0.2916 according to cent, 0.2819 in step with cent, 0.1132 according to cent and 0.2216 consistent with cent.

CONCLUSION

Empirical evidence gathered through the case study of MSMEs in Madurai district, several key determinants emerged as influential factors in their growth and development. The findings suggest that a combination of strategic initiatives, supportive policies, and favorable market conditions has played a pivotal role in fostering the expansion of these enterprises. The study revealed a notable rise in job creation within the MSME sector. This growth in employment has not only alleviated unemployment rates but has also stimulated local economic activity and consumer spending. Furthermore, the total investment made by MSMEs in Madurai district has witnessed a substantial surge. Directed towards modernizing production facilities, upgrading technology, and expanding business operations. Such investments have enhanced the efficiency and competitiveness of MSMEs, enabling them to cater to a wider market and capture new business opportunities. The sales performance of MSMEs in Madurai has also been impressive. The study observed a significant increase in both sales and revenue. This growth in sales can be attributed to factors such as improved product quality, effective marketing strategies, and a growing demand for MSME- produced goods and services. In particular, the motorcycle shops operating within the MSME sector in Madurai have demonstrated commendable progress. These businesses have exhibited higher levels of efficiency and have successfully met the increasing demand for motorcycles and related services. This growth can be attributed to factors such as skilled workforce, reliable supply chains, and competitive pricing. Many MSMEs struggle to secure adequate funding to expand their operations, invest in new technologies, and meet working capital requirements. This lack of financial resources can constrain growth and limit their ability to compete effectively. Another significant challenge faced by MSMEs is the difficulty in selling their products and services. Market access, distribution channels, and brand recognition can be obstacles for smaller enterprises. Limited marketing resources and a lack of awareness about their offerings can hinder their ability to reach potential customers and generate sales. Moreover, technical guidance and support are often lacking in the MSME sector. Many entrepreneurs may require assistance in areas such as technology adoption, quality control, and business management. The absence of adequate technical support can limit the growth potential of MSMEs and hinder their ability to innovate and remain competitive. In conclusion, the case study of MSMEs in Madurai highlights the multifaceted factors influencing their growth and development. While the region has witnessed significant progress with employment generation, investment, sales, finance, market access, and technical guidance persist and the ensuring the continued growth of MSME sector in Madurai district.





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SUGGESTIONS FOR ENHANCING MSME GROWTH IN MADURAI DISTRICT

Financial Support

- Loan Programs: Implement targeted loan programs with flexible repayment terms and lower interest rates to address the financial constraints faced by MSMEs.
- Credit Guarantee Schemes: Establish credit guarantee schemes to mitigate the risk faced by lenders, thereby increasing access to finance for MSMEs.
- Venture Capital and Angel Investing: Promote venture capital and angel investing to provide equity financing for innovative MSMEs with high growth potential.

Market Access and Promotion

- Trade Fairs and Exhibitions: Organize regular trade fairs and exhibitions to facilitate B2B and B2C interactions, and enhance market visibility for MSMEs.
- Online Marketplaces: Develop or support online marketplaces specifically designed for MSMEs to connect them with a wider customer base.
- Branding and Marketing Assistance: Provide branding and marketing assistance to MSMEs, including training programs and subsidies for marketing activities.

Capacity Building and Skill Development

- Training Programs: Offer vocational training programs to enhance the skills of MSME workers, improving productivity and quality.
- Business Management Workshops: Conduct business management workshops to equip MSME entrepreneurs with essential skills such as financial management, marketing, and operations.
- Technology Adoption Support: Provide technical assistance and subsidies for MSMEs to adopt modern technologies and improve their competitiveness.

Infrastructure Development

- Industrial Parks: Establish well-equipped industrial parks with essential and transportation, to attract MSMEs.
- Technology Incubators: Create technology incubators to foster innovation and provide support services to start-up MSMEs.
- Improved Connectivity: Enhance connectivity through improved roads, railways, and telecommunications infrastructure to facilitate services.

Policy Reforms

- Regulatory Simplification: Streamline regulatory procedures and reduce bureaucratic hurdles to improve the ease of doing business for MSMEs.
- Tax Incentives: Provide tax incentives and exemptions to MSMEs to encourage investment and growth. By implementing these suggestions, Madurai district can create a more conducive environment for MSME growth, leading to increased employment opportunities, economic development residents.

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Table 1 : Score Values in Level of Growth of Msme

Sl. No	Level of Growth	Number of MSMEs	Total Score	X	S.D.	C.V. %
1.	High	20	3861.21	19	8.14	9.91
2.	Medium	52	6621.46	35	3.64	7.06
3.	Low	28	2491.36	38	3.93	12.52
		100	12974.23	52.69	4.16	7.99

Table 2 : Indicates the Growth Rates of MSMEs in Madurai District

Variables	Parameter Estimates		
	High Level	Medium Level	Low Level
Intercept	1.9631	2.1514	2.0129
Log X1	0.0745	0.1015	0.0081
	(0.1315)	(0.0951)	(0.0036)
Log X2	0.2916*	0.2931*	0.1939*
	(2.1916)	(3.0181)	(2.7315)
Log X3	0.1131*	0.2131*	0.1346
	(0.1211)	(2.2411)	(0.9531)
Log X4	0.2819*	0.2231*	0.3211*
	(3.1521)	(2.0511)	(4.0149)
Log X5	0.1132	0.1131	0.0198
	(1.9916)	(0.0345)	(1.0091)
Log X6	0.0816	0.1036	0.0113
	(0.1719)	(0.1131)	(0.1431)
Log X7	0.1311*	0.3435*	0.2219*
	(0.0321)	(2.1131)	(3.1921)
Log X8	0.1031*	0.1315	0.0646
	(0.0315)	(0.0346)	(1.0018)
Log X9	0.2216*	0.1116	0.1362
	(2.9561)	(0.1316)	(0.1041)
Log X10	0.1321*	0.1326	0.1321
	(0.0631)	(0.2116)	(0.0921)
R ²	0.5315	0.5541	0.5121
F-Value	27.4511	32.6311	19.261
No of Observation	20	52	28

t-values for brackets.

(*) co-efficients the 5% level significant.





The Role of Innovation in the Modern Era: Insights into Autonomous Vehicle Adoption in Bengaluru

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ABSTRACT

Artificial intelligence has seeped into all sectors of the economy and is transforming how systems and businesses operate. It increases efficiency in healthcare, education, finance, manufacturing, and retail—not just this, but even in the automobile industry, where artificial intelligence is very prominent. Autonomous vehicles use artificial intelligence, machine learning, and sensor technologies. Self-driving cars operate without requiring or limiting human drivers' involvement in taking over. By removing the variability associated with human drivers, self-driving cars can greatly increase highway capacity. The study aims to find the factors affecting behavior intention towards AV. With a sample size of 251 sample, SEM, specifically the PLS tool, was used to verify the proposed theoretical model. The most significant variable in deciding the behavior intention toward autonomous vehicles is the utilitarian motive (UM), which means people will buy autonomous vehicles if they get better utility than conventional, manual automobiles. Other important factors having a positive and significant impact on the BIU Avs are environmental Benefits, PIIT, and Economic Benefits. One of the important factors for refraining from using autonomous vehicles are technology anxiety, which means that people who have technology anxiety is likely to refrain from buying autonomous vehicles. India is prepared to allow autonomous vehicles on the roads, much like most affluent nations. However, policy measures and the encouragement of research and development are required to make this happen. This would contribute to India's development while lowering the number of traffic accidents, reducing congestion, lowering parking costs, and Fuel Saving.

Keywords: AV-autonomous vehicles, behavior intention to use, PLS-SEM.



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INTRODUCTION

AI is changing the world in numerous ways by transforming industries, economies, and daily lives. This is one of the greatest technological revolutions as AI is enabling machines to perform tasks that usually require the intelligence and decision-making skills of humans. One such exceptional application of AI is automobile in the automobile field that is autonomous vehicles. Autonomous vehicles are self-driving vehicles, and they operate without human intervention. It uses technologies like machine-learning algorithms, and sensor technologies like LiDAR, radar, and cameras research has found that autonomous helps to reduce the chances of accidents and help to manage traffic by making real-time decisions and navigating complex environments. There are six levels of autonomous as defined by the Society of Automated Engineers (SAE) ranging from level, 0 to level five, and levels one and two are widely used.

Autonomous Vehicles in the Present Day

With leading advancements of companies like Tesla, Waymo, and Uber AV has developed from basic to real-world application. Tesla provides a semi-autonomous driving experience while Waymo gives a fully auto-driving experience in a few regions. In 2019, there were 31 million autonomous vehicles on the road, and it's predicted that by 2035, it will be around 50 million the value of the global autonomous vehicle market is worth \$33.45 million as of 2023. China, Japan, and Singapore are the top three Asian countries in terms of AV testing, despite infrastructure and regulatory barriers. Despite challenges like poor infrastructure and convoluted traffic, India is becoming a significant competitor because of companies like Minus Zero that are creating regional solutions like Z Pod, India's first AV. The government of India is also supporting AV's adoption as a sustainable transportation option. In Indian automobile industries like Mahindra & Mahindra and Tata Motors, are also investing in AV technologies like advanced driver assistance systems (ADAS) and systems to avoid collisions. India's automotive sector contributes significantly to GDP, is expected to grow with the introduction of AV and by 2026 is projected to hit \$300 billion. As autonomous vehicles (AVs) advance, they are expected to yield environmental advantages, reduce traffic, and enhance safety. Countries like Asia and India might greatly improve their economies by integrating autonomous vehicles (AVs) into their transportation networks, there are challenges to be solved including public acceptance, infrastructure development, regulatory considerations, and technical readiness.

REVIEW OF LITERATURE

Behavioral Intention to Use(BIU)

According to Ji and Choi's 2015 study behavioral intention to use an information technology depends upon the perceived utility and ease of use. Many studies (Chau & Hu, 2002; Sheppard, Hartwick, & Warshaw, 1988; Wu, Shen, Lin, Greenes, & Bates, 2008) have found that Behavioral intention, as opposed to actual usage, is a particularly useful dependent variable when studying the early adoption of technological systems. Jing et al. 2019 found that individuals who are young, educated, middle-class, and people who live in cities are more likely to use Avs.

Personal information technology innovativeness(PIIT)

Innovativeness refers to the degree to which an individual relatively adopts innovation earlier than another individual as a member of the social system (Rogers & Shoemaker, 1971). PIIT was created to quantify a person's inclination to experiment with any information technology (Agarwal & Prasad, 1998). Simarmata & Hia, n.d., 2020 have shown in their empirical study that the use of Information technology, over time increases intention to use the technology. Agarwal & Prasad, 1998 concluded that the willingness of one person to experiment with advanced technology increases the PIIT. Similarly to, research on personal innovativeness positively correlates with intending to use location-based services (LBS) to give prospective users marginally supported results (Xu & Gupta, 2009). Hwang, 2014 has highlighted the significance of the PIIT construct in elucidating people's attitudes to the use of technology.



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H_{1a} – Personal Innovativeness in Information Technology (PIIT) has a positive impact on the Behavioural intention to purchase an AV.

Utilitarian motivation

Motivation is an internal state that propels a person's willingness to act and forces them to satisfy their basic needs (Ryan and Deci, 2000). Utilitarian motivation refers to purchasing a product for functional and economic benefits. The primary objective of utilitarian systems is to give the user instrumental value, such as knowledge to complete a task (Van Der Heijden, 2004). We conclude that utilitarian benefits (like perceived usefulness and performance expectancy) are important considerations when deciding whether to accept AVs (Kasper & Abdelrahman, 2020). H_{1b} – Utilitarian Motives positively impact the Behavioural intention to purchase AV.

Economic benefits

A benefit can be expressed numerically as an amount of money that will be saved or generated as the result of an action. Since actual usage of AV technology cannot yet be tested due to its limited availability, the empirical research reviewed in the previous studies only looks at the BIU as the outcome variable and does not investigate its further outcomes (Keszey, 2020). Fagnant & Kockelman, 2014 found that AVs have many economic benefits including savings from fewer crashes, reduced congestion costs, and saved parking costs. Both new and established car manufacturers conduct the development and manufacturing of autonomous vehicles (AVs). With a global market of 44 million vehicles, it is anticipated that by 2035 there will be 75% more autonomous vehicles than there were in 2030, which will have a 71-billion-dollar economic influence on the automotive sector (Curto et al., 2021). H_{1c} – Economic Factors positively impact the Behavioural intention to purchase AV.

Technological Anxiety(TA)

Technological anxiety is the propensity for people to feel uneasy, nervous, or afraid when utilizing cutting-edge technological products like AV (Igbaria et al., 1996). Customers who are truly worried about technology are less likely to interact with complex products (Meuter et al., 2003). Concerns about data security and privacy (such as GPS tracking and smartphone access) are also covered by anxiety. Among the most widely recognized obstacles to technology adoption are resistance to technology and the incapacity to accept new technologies (and the changes they bring about in users' lives) (Davis, 1993, Keszey, 2020, Zmud et al. 2016). H_{1d} -Technological anxiety has a negative impact on the behavioral intention to purchase AVs.

Data privacy Concerns

Keszey 2020, found that data privacy is one of the most important factors affecting Behavioral intention to use AVs. For instance, a recent study showed 93% of the Participants voiced worries about data privacy, with identity theft and fraud being the most serious issues (Clement, 2019). Concerns about data privacy relate to an individual's susceptibility as an outcome of losing control over how personally identifiable information is managed by third parties, like businesses or organizations (Martin et al., 2017). People would only plan to use AVs if they were related, and connected technology offers adequate security and privacy protection for data (Panagiotopoulos and Dimitrakopoulos, 2018). The biggest concern regarding AV is the possibility of safety problems caused by the fear of hacker attacks, unauthorized tracking, and misuse of personal information (König & Neumayr, 2017). Data privacy concerns can be reduced by providing strong data privacy protection to AVs users. H_{1e} – Data Privacy has a negative impact on the Behavioural intention to purchase AV.

Environment Benefit

Hao and Yamamoto (2018) in their review study have highlighted the benefits of AVs and SAVs. AVs can lower the greenhouse effect, reducing congestion by optimizing the routes and reducing ownership of vehicles through SAVs. H_{1f} – The environmental benefit has a significant impact on the Behavioural intention to purchase an AV. Since the world is rapidly growing and evolving in terms of technology there is a major need to check people's preferences related to the automobile industry. Moreover, Autonomous vehicles have the scope to solve many personal travel problems varying from Safety, reducing congestion, lowering parking costs, safety, and Fuel Saving. There is much



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literature that explains AVs, but not many Indian studies have been done in this field. Though Autonomous vehicles are not available in India, it is important to know the Behavioral attitude towards Autonomous vehicles that will be an incentive for the Government to come up with a policy on AVs that is data-driven Vehicle and can provide important insight to car manufacturing firms. The current study objective is to explore and provide an assessment of factors affecting the behavioral intention to use level 3 Avs among the citizens of Silicon Valley (Bengaluru) of India.

Theoretical Framework

The study is based on the theoretical framework of the Unified Theory of Acceptance and Use of Technology, introducing the UTAUT2 model developed by Venkatesh in 2012. This model is developed to understand the factors affecting the acceptance of new information technologies by its users. The UTAUT2 model includes many factors like Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Hedonic Motivation, Price Value, and Habit, those are factors that explain the user's decision to adopt and use the technology (Venkatesh, 2012).

Data Analysis

This study develops a key research question: What are the key factors influencing the behavioral intention to use Autonomous Vehicles (AVs) among citizens of Silicon Valley (Bengaluru), India? And covers Behavioral intention to use (BIU) Avs, a fundamental component of the UTAUT2 (Venkatesh, 2012). The study used 18 items for seven constructs and modified them to be relevant to the research. After a pilot study was completed on 30 Bengaluru samples, a reliability test using Cronbach's alpha was performed on the questionnaire. All constructs were evaluated using reflecting modeling, followed by PLS-SEM in smart PLS, a commonly used multivariate analytical process (Hair et al., 2019). Primary data was collected from 251 citizens varying ages between 18 to 50 years in Bengaluru and was used to arrive at various results and draw conclusions from the same. The descriptive Statistic is given in Table 2

Assessment of measurement model

Before the structural model was assessed, Confirmatory Factor Analysis (CFA) and Discriminant validity were established. All the values show satisfactory results. In conclusion, there is no issue of reliability, validity, or multicollinearity. The model specifies causal relationships between all constructs of interest. Path coefficient and R^2 show that data supported the hypothesized model. The analysis was performed on the complete sample of 251 shown in fig 1 and Table 4. The results in Table 4, indicate that PIIT has positive significant effects ($\beta=0.198^{**}$, $p<0.00$), utilitarian motivations have significant, positive effects ($b = 0.258$ $p <.000$); Economic benefits have a positive significant effect ($b= 0.113$, $P<0.05$); technological anxiety has a significant negative effect ($b =-0.252$, $P<0.00$) and Environmental benefits have a significant positive effect ($b=0.225$, $P<0.00$) but data privacy has a negative and insignificant effect on the BIU. Hence H_{1a} , H_{1b} , H_{1c} , H_{1d} and H_{1f} are accepted but H_{1e} is rejected. The results show that out of six factors, five factors have significantly accounted for 36.8% of the variance in behavioral intentions to use Avs. The results have shown that PIIT has a positive significant impact on the BIU as a result aligned with the studies of Agarwal & Prasad, 1998, Simarmata & Hia, n.d., 2020, Xu & Gupta, 2009. Thus, the willingness of one person to experiment with advanced technology increases the BIU Avs. Hypothesis H_{1c} BIU Avs will positively impact the economic benefits of Avs as Avs will lead to an increase in savings from fewer crashes, reduced congestion costs, and saved parking costs (Keszey, 2020, Fagnant & Kockelman, 2014). To encourage the use of Avs, (H_{1f}) the environmental Benefit has a positive and significant ($b=0.225^{***}$) impact on the BIU Avs, as highlighted in the study by Hao and Yamamoto (2018).

DISCUSSION

The aim is to explore the role of Data privacy, Economic benefit, Environmental benefit, PIIT, Technological anxiety, and Utilitarian motivations in determining the behavioral intention to use Avs. The examination results show that the economic benefit, environmental benefit, PIIT, technological anxiety, and utilitarian motivation factors are statistically significant and have a positive impact on predicting the behavioral intention of the user. Empirical results of the studies have proposed new antecedents as utilitarian motivation, Environmental benefits, and economic



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benefits have the maximum impact on the BIU Avs that satisfies the UTAUT2. The results have shown that the most important factor affecting the BIU is the Utilitarian Motivation of the Avs. Therefore, there will be a strong desire among users to use the Avs if they perceive them to be beneficial. Technological anxiety harms BIU Avs. The results aligned with the prior studies (Zmud et.al, 2016). To reduce technological anxiety there is a need to have strong data privacy and safety laws. It is important to highlight the methodological limitations of the study that may limit the generalizability of the results. Several questions about Behavioral intention to use Avs thus need further attention. The study can be extended to examine how respondents' demographic, impact their opinions and attitudes towards the Use of Avs. The above research is restricted to seven factors only but there are other factors like hedonic motivation, and the price of Avs will also affect the BIU Avs.

Policy Recommendations

The study contribute to the knowledge of the policymakers and the firms looking for the opportunity for the manufacture and selling of Avs in India, specifically in Bengaluru. This study affords insights for car manufacturers and self-sustaining gadget designers to meet user wishes and enhance offerings. Understanding the elements influencing consumer recognition of autonomous technology is critical for advertising and marketing corporations to allocate sources correctly, given the tremendous investments in those systems. For example, technical anxiety has a significant negative impact on BIU. AV vehicle stakeholders can organize sessions to make users aware of safety measures, cost-effectiveness, and robustness of AVs. Most of the developed countries, like China, the UK, and Singapore are using and improving on AVs, and India too has huge scope for AVs as the car market grew by 26.7% in FY 23. But to bring AVs to the road there is a need to have a data-privacy policy for the safety and privacy of the user data and infrastructural development is required.

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Table 1: Descriptive Statics

Demographic variable	Frequency	percent
Gender		
Male	127	50.60
Female	124	49.40
Educational Qualification		
Diploma	16	6.37
Undergraduate	126	50.20
Postgraduate	97	38.65
Ph.D.	12	4.78
Occupation		
Business	34	13.55
Government	18	7.17
Private	140	55.78
Others	59	23.51
Income level(annual)		
Less than 5 lakhs	34	13.55
5 lakhs to 10 lakhs	140	55.78
10lakh -20 lakh	59	23.51
more than 20 lakhs	18	7.17
Car Ownership		
Yes	136	54.18
No	115	45.82
Awareness about Avs		
Yes	224	89.24
No	26	10.36
If, yes from where		





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Newspaper	30	11.95
Television	22	8.76
Social media	160	63.75
Other	33	13.15

Source: Author's Calculation

Table 2:Construct Reliability and validity

Variables	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Behaviour	0.83	0.839	0.899	0.748
Intention (BIU)				
Data	0.834	0.835	0.901	0.752
Privacy (DP)				
Economic factor (ECO F)	0.66	0.741	0.802	0.579
Environmental Factor (EF)	0.827	0.865	0.919	0.85
Personal information technology innovativeness (PIIT)	0.547	0.628	0.807	0.679
Technology	0.712	0.948	0.863	0.76
Anxiety (TA)				
Utilitarian Motive (UM)	0.812	0.816	0.888	0.727

Source: Author's Calculation

Table 3 : BOOTSTRAPPING VALUES on Behaviour Intention

Hypothesis	Item	sample (O)	T statistics (O/STDEV)	P values	Decision	
H1a	PIIT -> BT	0.198	3.759	0	Significant	Supported
H1b	UM -> BT	0.258	4.1	0	Significant	Supported
H1c	ECO -> BT	0.113	2.247	0.012	Significant	Supported
H1d	TA -> BT	-0.252	5.461	0	Significant	Supported
H1e	DP -> BT	-0.045	0.772	0.22	Insignificant	Unsupported
H1f	ENV -> BT	0.225	3.59	0	Significant	Supported

Source: Author's Calculation

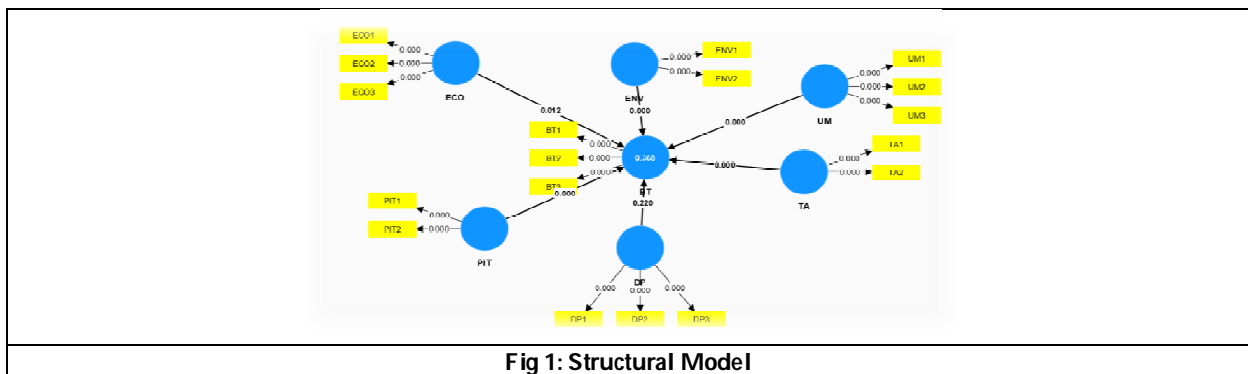


Fig 1: Structural Model





RESEARCH ARTICLE

A Study on Socio - Economic Impact of Covid – 19 on Women Entrepreneurs in Bangalore

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ABSTRACT

The present study delves into the socio-economic obstacles encountered by female entrepreneurs in Bangalore, India, during the post-COVID-19 period, emphasizing their adaptability and resilience. The principal aims comprise of identifying the hindrances faced and investigating the actions implemented to ease these difficulties. Data were collected using a self-administered, standardized questionnaire, and then evaluated using correlation analysis, chi-square testing, and descriptive statistics for analysis. Important findings show substantial effects on the economy, including challenges in obtaining loans and venture capital along with supply chain interruptions that affect operational effectiveness and quality control. According to socioeconomic characteristics, the majority of female businesses faced difficulties with digital operations and decreased profit margins. Many responded by implementing e-commerce plans, looking for assistance via social media platforms, and making fiscal cutbacks. The results of the study indicate that in order to empower women entrepreneurs, it is essential to provide them with focused technological training, improved supplier relationships, alternative financing choices, and solid inventory management. Stakeholders can create an environment that promotes the steady expansion and adaptability of women-owned enterprises amidst persistent obstacles by putting these suggestions into practice.

Keywords: Women entrepreneurs, COVID-19, Socio-economic challenges, E-commerce, Resilience



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INTRODUCTION

Entrepreneurship is a key factor in globalization since it stimulates economic growth and innovation. It involves identifying possibilities to enhance current solutions or address gaps in the market, advancing both societal and economic advancement. Through innovation, diversity, and moral behaviour, entrepreneurship promotes social transformation in addition to financial gains. In the process of empowering people individually and collectively, it fosters competition, brings in fresh perspectives, and produces jobs. The article examines how entrepreneurship is complex and has a big influence that goes beyond financial metrics.

Scope of the study

The socioeconomic effects of COVID-19 on female entrepreneurs in Bengaluru, India, are explored in this study. It focuses on how the pandemic has affected women-owned businesses, notably in terms of funding, technology absorption, and operational issues. The study also looks at the methods used by female business owners to overcome these obstacles, such as using digital tools and cost-cutting techniques. It also assesses the usefulness of government aid initiatives and the function of networking groups for female business owners. The study's overall goal is to give policymakers information they can apply to create pertinent assistance programs.

OBJECTIVES OF THE STUDY

The current study has the following objectives

- To identify and analyze the challenges faced by women entrepreneurs in the post COVID era.
- To explore the measures taken by women entrepreneurs to overcome the challenges posed by the COVID -19 pandemic.

METHODOLOGY

Sample

This study utilised a descriptive research design to analyse the obstacles and strategies faced by forty female entrepreneurs based in Bengaluru, India. The sample population consisted of 40 female entrepreneurs working in Bengaluru, India. An industry-wide diversified sample of 45% product-based businesses, 30% product-service firms, and 25% service-oriented businesses was made possible by the use of the snowball sampling technique.

Methodology

A self-administered, standardized questionnaire that was initially assessed for relevance and clarity was used to collect data. The study applied descriptive statistics, such as pie charts and bar graphs, to examine the distribution of firms and demographic data. The relationships between characteristics and barriers to entrepreneurship were investigated using chi-square testing and correlation analysis. Strict adherence to ethical standards guaranteed participant privacy and informed consent. The objective of this research approach was to offer a thorough understanding of female entrepreneurship in Bengaluru, with significant implications for policy and practice in comparable settings.

RESULTS AND DISCUSSIONS

ECONOMIC IMPACT - CHALLENGES

Women entrepreneurs encounter specific challenges that make it difficult for them to thrive, hence understanding challenges is important and create a just environment for them. Objective - 1: To identify and analyze the challenges faced by women entrepreneurs in the post COVID era. Women entrepreneurs encounter specific challenges that make it difficult for them to thrive, hence understanding challenges is important and create a just environment for them.



**Alvina Paul and Shanthi****Hypothesis-I**

H₀: There is no significant correlation between disruptions in the supply chain, delays in receiving essential equipment, and difficulties in maintaining quality control standards among women entrepreneurs in the post-Covid era.

H₁: There is a significant correlation between disruptions in the supply chain, delays in receiving essential equipment, and difficulties in maintaining quality control standards among women entrepreneurs in the post-Covid era. The study found a moderate negative correlation between disruptions in the supply chain and both delays in receiving essential equipment (-0.45) and difficulties in maintaining quality control standards (-0.26). This indicates that as supply chain disruptions increase, there is a tendency for delays in receiving essential equipment to also increase, and to a lesser extent, difficulties in maintaining quality control standards. However, a weak positive correlation (0.097) was observed between delays in receiving essential equipment and difficulties in maintaining quality control standards, suggesting a slight tendency for these issues to be associated with each other.

Hypothesis -II

H₀: There is no significant correlation between challenges related to technological barriers, acquisition costs of technology, and insufficient technical skills within the team among women entrepreneurs in the post-Covid era.

H₁: There is a significant correlation between challenges related to technological barriers, acquisition costs of technology, and insufficient technical skills within the team among women entrepreneurs in the post-Covid era. The study found very weak negative correlations between technological barriers and both the cost of technology (-0.054) and technical skills (-0.057), suggesting little to no linear relationship between these factors. However, a moderate positive correlation (0.56) was observed between the cost of technology and technical skills, indicating a tendency for higher acquisition costs of technology to be associated with better technical skills within the team, and vice versa.

MEASURES UNDERTAKEN BY WOMEN ENTREPRENEURS

Despite pandemic challenges female entrepreneurs displayed resilience through necessary measures to overcome the challenges.

Objective - 2: To explore the measures taken by women entrepreneurs to overcome the challenges posed by the COVID -19 pandemic.

Hypothesis-I

H₀: There is no significant association between the strategies implemented to reduce costs and the specific cost-saving measures adopted by women entrepreneurs.

H₁: There is significant association between the strategies implemented to reduce costs and the specific cost-saving measures adopted by women entrepreneurs. The study found that there is no significant association between the strategies implemented to reduce costs (such as employee pay cuts or layoffs) and the specific cost-saving measures adopted (such as rent reduction, inventory management, or utility bill reduction) by women entrepreneurs in post COVID-19 pandemic. This is indicated by a p-value of 0.06, which is greater than the conventional significance level of 0.05. This implies that factors other than the strategies themselves, such as industry dynamics, business size, financial resources, market conditions, and regulatory environment, may influence the selection of cost-saving measures by women entrepreneurs. Therefore, we accept the null hypothesis.

Hypothesis - II

H₀: There is no significant association between the implementation of new digital tools or software and the expansion of geographical reach due to digital transformation efforts among women entrepreneurs.

H₁: There is a significant association between the implementation of new digital tools or software and the expansion of geographical reach or reaching new markets due to digital transformation efforts among women entrepreneurs. The study found no significant association between the implementation of new digital tools or software and the expansion of geographical reach or reaching new markets among women entrepreneurs. This is indicated by a p-value of 0.367, which is greater than the conventional significance level of 0.05. Here we accept the null hypothesis. This suggests that while women entrepreneurs may be adopting digital tools and software for managing operations,





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customer relations, and marketing, these efforts do not necessarily lead to significant improvements in geographical reach or market expansion.

SOCIO IMPACT

The variable taken are skills and knowledge, government support, future perspective and support systems.

Government Awareness regarding Support

Level of Awareness: Less than half (45%) of female entrepreneurs were aware of government support initiatives during the COVID-19 pandemic.

Government Measures' Efficacy

Helpfulness: Only 15% of the 45% who were aware of these measures thought they would be beneficial to their company.

Platforms for networking and support

Use: 65% of female entrepreneurs actively participated in support groups or networking sites, appreciating the unity and cooperation found in the female entrepreneur community.

Future Dependency on Digital Instruments

92.5% of female entrepreneurs see a future where technology and digital tools will be used extensively.

KEY FINDINGS OF THE STUDY

Objective I:

To identify and analyze the challenges faced by women entrepreneurs in the post COVID era.

Economic Impact

Access to Finance

- a) Loan Acquisition: Securing loans from financial institutions was a challenge for most women entrepreneurs after the pandemic, with service businesses being the most impacted.
- b) Venture Capital/Angel Investment: While product-service businesses had a higher success rate, securing funding from VCs or angel investors remained a challenge for some.
- c) Supply chain disruptions negatively impact both equipment arrival time (-0.45) and quality control (-0.26). Delayed equipment arrival further contributes to quality control challenges (0.097).
- d) There is a very weak negative correlation between technological barriers and both the cost of technology (-0.054) and technical skills (-0.057). However, a moderate positive correlation exists between the cost of technology and technical skills (0.56).

Socio Impact

1. 55% of women entrepreneurs found it challenging to manage digital operations due to inefficient skills and knowledge.
2. 87% of women entrepreneurs faced a negative impact on profit margins.

Objective II:

To explore the measures taken by women entrepreneurs to overcome the challenges posed by the COVID -19 pandemic.





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Economic Impact

- 1) There is no statistically significant association ($p\text{-value} = 0.06 > 0.05$) between cost-reduction strategies (e.g., layoffs) and specific cost-saving measures (e.g., rent reduction) adopted by women entrepreneurs post-COVID, suggesting other factors influence cost-saving choices by chi squared test.
- 2) Digital tool implementation (for operations, customer relations, and marketing) was not statistically linked to geographical reach expansion ($p\text{-value} = 0.367 > 0.05$), suggesting these tools may address internal needs without directly impacting market reach by chi squared test.
- 3) E-commerce Adoption: 77.5% of the women entrepreneurs strategically shifted towards online sales channels.

Socio Impact

1. A significant majority of women entrepreneurs sought connection and support by utilizing networking platforms or support groups.
2. 45% women entrepreneurs were aware of the government measures and only 15% among them found it useful.
3. A significant majority (65%) of women entrepreneurs actively sought connection and support by utilizing networking platforms or joining support groups

SUGGESTIONS

- In order to overcome obstacles in obtaining loans, particularly for service-oriented firms, female entrepreneurs should investigate alternate kinds of funding such as grants, crowd funding platforms, and angel investors who are specifically focused on women.
- Women entrepreneurs can benefit from using strong inventory management to maximize stock levels and protect against delays in production or sales.
- Make training investments to optimize the return on technology investments, taking into account the positive link between technical and cost.
- Use digital tools to increase internal efficiency first so that resources can be allocated to additional market expansion tactics.
- Women business owners ought to devote more time to learning how to fully utilize digital tools for marketing.

CONCLUSION

This study analyses the socioeconomic effects of COVID-19 on female entrepreneurs in Bangalore, India, highlighting barriers including lack of funding, disruptions in the supply chain, and technology constraints. They overcame these challenges by using networking platforms and online sales channels to show resiliency. Policy and corporate interventions, such as improved supply chain management, alternate finance sources, and targeted investments in technology and talent development, are required to enable their sustained growth. In spite of persisting obstacles, these steps can foster a climate that is conducive to the long-term development of women-owned enterprises.

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Table 1: Correlation values – I

CORRELATION	VALUES
Supply chain and equipment	-0.45
Supply chain and quality control	-0.26





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Equipment and quality control	0.097
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Table 2: Correlation matrix - II Data we_1

	supply chain	equipment	quality control
supply chain	1.000000	-0.448109	-0.263329
equipment	-0.448109	1.000000	0.096824
quality control	-0.263329	0.096824	1.000000

Table 3: Correlation values – II

CORRELATION	VALUES
Technological barriers and cost of technology	-0.054
Technological barriers and technical skills	-0.057
Cost of technology and technical skills	0.56

Table 4: Correlation matrix - II

	technological barriers	costs of technology	technical skills
technological barriers	1.000000	-0.054045	0.056652
costs of technology	-0.054045	1.000000	0.556012
technical skills	0.056652	0.556012	1.000000

Table 5: Data: cont_table – I

Statistic	14.93
p-value	0.060
dof	8

Table 6: Data: cont_table - II

Statistic	17.28
p-value	0.367
dof	16





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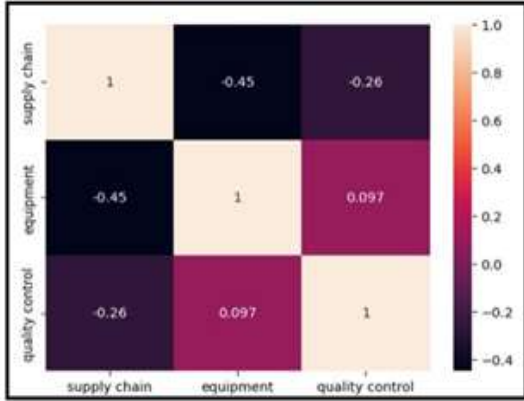


Fig 1: Heatmap 4.1(c) - I

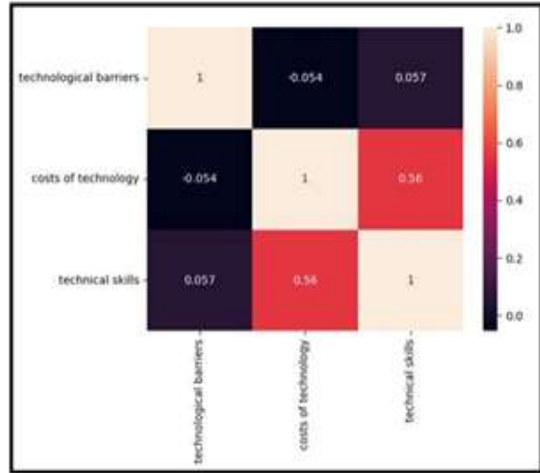


Fig 2: Heatmap 4.2(c) - II





A Study on the Impact of Entrepreneurial Practice Among Students

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ABSTRACT

Educational institutions and their adaptive, flexible ecosystem open a lighted pathway of opportunity, creativity, design thinking, knowledge, and motivation among students and academicians. The study aimed in showcasing a practical action-oriented entrepreneurial practice and understand its impact. The Educational, Technological, Entrepreneurial and Social impact about the practice was studied using a structured questionnaire. 100 students of the institution were interviewed and the data was analysed. The study proved that the entrepreneurial practice of product development and marketing done by the students was a reflection of the knowledge and opportunity assimilated from the institution. Educational Institutions should include more practical aspect than theoretical in order to allow the students, practice entrepreneurship and get a real-life experience. Though there were challenges and limitations mentioned, the overall impact was positive, which had brought in skilled, creative and socially responsible young adults which paved way to climb the initial steps of entrepreneurship as budding entrepreneurs.

Keywords: Entrepreneurial Education, Entrepreneurial Culture, Ecosystem.

INTRODUCTION

Entrepreneurship does not demand academic qualification. However, to become successful entrepreneurs, both practical experience and formal education will be effective. Entrepreneurship education is a tool which can be used to attain positive students' intentions towards entrepreneurship (Jianpeng, 2024). Entrepreneurship is when an individual who has an idea act on that idea, usually to disrupt the current market with a new product or service (Adam Hayes, 2024). Entrepreneurial culture is an emerging discipline where someone is motivated to innovate, create and take risks and create an impact on the growth of economy through educational institutions. Flexibility, adaptability, a growth mind-set, and a learning orientation are key components of entrepreneurial culture that can lead to long-term success. (Nasia, 2024). Government and non-government organizations should instigate

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educational institutions to plan and implement entrepreneurship training programs with business organizations, governments and other relevant stakeholders in the local environment (Onu, 2013). Policymakers are encouraged to follow policies to improve entrepreneurial culture growth by promoting strategic cooperation among stakeholders and educational institutions implementing several concepts to enhance entrepreneurial culture. (Al-Lawati, 2022).

Statement of the problem

The concept of promoting and instilling entrepreneurial culture in students have paved way towards developing a bunch of budding entrepreneurs from the student community to face the world of entrepreneurship and its challenges to become successful entrepreneurs. This study intends to overview the significance of educational institutions in fostering entrepreneurial culture among the student community and how the institutions can act to nurture and frame an ecosystem to bring out aspiring entrepreneurs from classroom to market. Every educational institution should include practical component of entrepreneurship along with theoretical aspect to contribute to economy, render practical experience of entrepreneurship and gain real life experiences. In this context, the study emphasis the role of Skill India Mission by Government of India which incorporates skill-based training programs in the school and college curriculum with certifications from industry-recognised learning centres. Henceforth, the Skill India Mission has become one of the best education institutes in India (Skillindiamission Blog, 2024). To substantiate this, the study projected the outcome and impact of an entrepreneurial activity conducted in one institution. This study focused on two objectives - (1) To overview the significance of the educational institutions and role played by organisations in emphasising and instilling entrepreneurial culture in institutions and (2) To show case the impact and output of a practical action-oriented entrepreneurial activity conducted.

METHODOLOGY

The study focussed on reviewing the significance of educational institutions in instilling entrepreneurial culture among students and faculties. To substantiate the concept of having practical aspects in entrepreneurship curriculum rather than only theoretical, a case study was conducted to evaluate the impact of one such practice in Mount Carmel College, Bangalore. The students of the Department of Home Science. were involved in an entrepreneurial practice of consumer product development and marketing inculcating all the elements of marketing and entrepreneurship since 2018. The tool used to study the impact was a structured questionnaire which was administered among the students, through purposive random sampling method. The sample size of the study was 100 which included current students and ex-students of the institution. The questionnaire consisted of 5 sections which included general information of the respondents, impact of entrepreneurial practice among students which was categorized as educational impact, entrepreneurial impact, technological impact and social impact, feedback from students about the entrepreneurial practice, strategies that educational institution could adopt to enhance entrepreneurial development and understanding about the entrepreneurial attitude among students. The data was interpreted and analysed.

RESULTS & INTERPRETATION

Educational institutions have a promising role to play in developing entrepreneurship. A study done in the University of Kashmir pointed out that the prevailing education system covers related business education and not entrepreneurship education. (Arshad, 2013). Recently entrepreneurship is been recognized as an academic discipline and has included theoretical models for formal education and learning (Valerio, Brent, Robb, 2014). Entrepreneurship education and incubation (including mentoring) are the factors that contribute directly to the quantity and quality of new startups and indirectly to the Indian economy (Nandini, 2022). Another study (Al-Lawati, 2021) aimed on the importance of entrepreneurial culture at educational institutions by analysing the relationship between entrepreneurial culture, entrepreneurship education (medium), and entrepreneurial intention (outcome) as study variables. In a study in Karachi on young entrepreneurs (Ammad Zafar, 2017), the researcher recommended the educational institutions (a) should set up entrepreneurship teachings as per international standard (b) should initiate courses that increase entrepreneurial intentions in students (c) should mentor and mould the students to face



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the corporate sector and (d) should provide a supportive platform to bridge the gap between student entrepreneurs and the corporate sector. As mentioned in the methodology of the present study, the results of the case study are discussed below.

General Information of the respondents

Among the 100 respondents, 78% of them fell under the age group of 20 to 25 years. 33% of the current students and 67% of ex-students responded to the survey. The data showed that among the 67% of the ex-students, 16% of them were working, out of which 10% were entrepreneurs. India's level of Total early-stage Entrepreneurial Activity (TEA) in 2023 was just under 12% (Sunil.et.al, 2023). Despite that, only 5 to 10% of these entrepreneurs take up the risk of building their ventures (Cheggindia, 2024). 21% of the entrepreneurs focused on food products, 19% had their startups in clothing field and remaining of them emphasized on cosmetics, accessories, decor and toiletries as their business venture. Majority (13%) had 5 to 7 years of experience as entrepreneurs,

Impact of the entrepreneurial practice

The Impact of entrepreneurship education and practice have profound effects on students, impacting their personal development, academic performance and career prospects. The result of the study is depicted below in Figure 1.

Feedback on the entrepreneurial practice

The benefits of entrepreneurship in educational institutions and the measure that can be adopted to enhance entrepreneurial skills in students were studied from the feedback obtained from students. 81% of the respondents opined self-employment as the major benefit through entrepreneurship. Boosting leadership qualities of students, creation of opportunities using the latest technologies, enhancement of creativity and innovative skills, learning basic life skills were few benefits mentioned by more than 50% of the students. In order to raise the quality of the entrepreneurial culture in students, the measures suggested by more than 50% of the students were, mentoring from business professionals to help the students to invest and manage entrepreneurial ventures, faculties who has business experience to initiate entrepreneurship in students, Increased practical components in the subject with entrepreneurship as one of major academic discipline, guiding the students to launch their products to the real market, gaining experience through internships, hand on workshop and skill development trainings from government and non-governmental organizations.

Limitations and Challenges

Financial constraints, limited network and connections, competitive market were the major issues commented by more than 55% of the students. Other problems mentioned were poor time management, lack of confidence, over expectations of customers and dealing with negative feedback. Similar results were obtained in study done on issues and challenges of startups in India (Susilaningsih.et.al, 2017). According to the study, the major issues and challenges faced by startups were poor finance and revenue generation, lack of efficient team members, unavailability of supporting infrastructure, ignorance about market trends, not able to meet consumer expectations, lack of mentorship and less knowledge on marketing strategies. Another study examined social issues, lack of proper technological infrastructure, financial issues and sustainability issues as few challenges faced by entrepreneurs during their initial phase of product launch. (Sumit, 2017) The challenges faced by budding entrepreneurs in institutions include lack of experience, competitive complex corporate world, and business education that is too theoretical and lack of real-life practical experience. (Sowbarnigadevi.et.al, 2022).

Entrepreneurial attitude among the students

50% of the students mentioned unawareness and poor knowledge in financial literacy is a must for stepping forward to startup and business ventures. Openness to criticism, being our own boss than some body's, more employment opportunities and growth and development of society were other positive attitude conveyed (Figure 2). In a study (Ali, 2011), when entrepreneurial attitudes from six public sector potential entrepreneurs of Pakistan were explored, majority of students showed generally positive attitudes towards entrepreneurship. Significant difference between negative and positive attitudes were derived from this study.





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Kedir (2011), in his study on entrepreneurial attitude found many areas of attitudinal difference between business and non-business students. The three most significant difference attitudes between business and non-business students were ability to make decision, creativity and persistence.

CONCLUSION

Entrepreneurship education and entrepreneurial culture play a significant role in fostering young entrepreneurs and pave way for self-employment. It also equips the students with positive entrepreneurial attitudes and skills required for start ups and to establish and stabilize their business venture consistently. Entrepreneurship education should include more practical component along with theory in order to give the students more entrepreneurial experience in real life situations. Government and non-governmental organisations should collaborate with educational institutions to build sound theoretical frameworks and implement entrepreneurial courses with trained faculties in order to raise the spirit of entrepreneurship in students.

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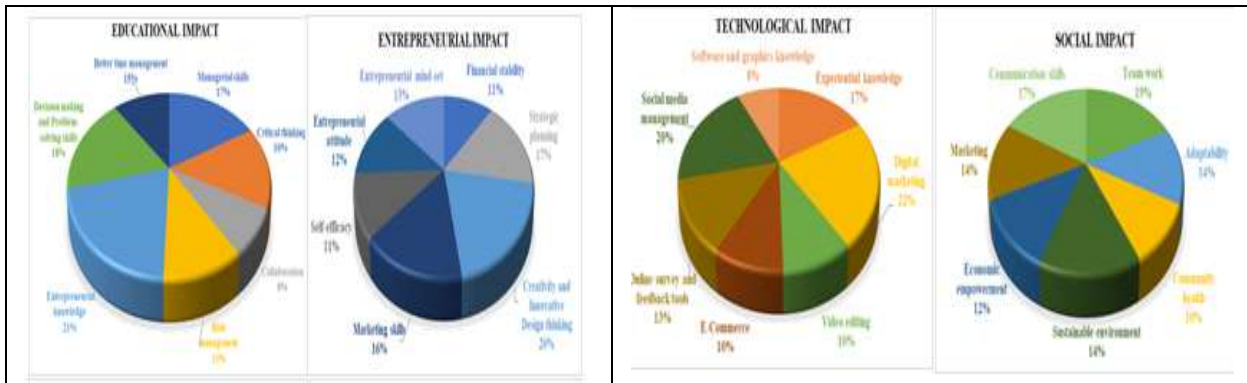


Figure 1: Impact of entrepreneurial practice on students

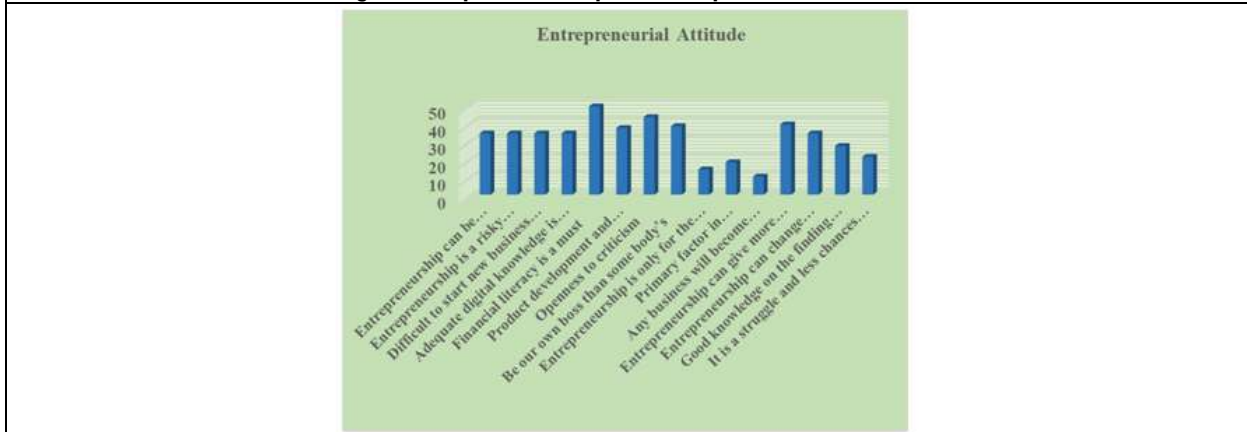


Figure 2: Entrepreneurial Attitude among Students





Tourism Entrepreneurship and Skill Development: A Systematic Review of the Impact on Innovation and Growth

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ABSTRACT

This systematic review examines the impact of skill development on entrepreneurial innovation and growth in the tourism industry. A comprehensive analysis of existing literature reveals that skill development enhances entrepreneurial capabilities, fosters innovation, and promotes tourism business growth in tourism. Key skills for tourism entrepreneurial success include technical, business, soft and digital literacy skills. Theoretical frameworks, including Human Capital Theory, Entrepreneurial Learning Theory, and Innovation Capital Theory, support the importance of skill development for tourism entrepreneurial innovation and growth. The review finds a positive relationship between skill development and entrepreneurial innovation in tourism, with tourism entrepreneurs possessing advanced skills more likely to innovate and adapt to changing market conditions. Skill development also has a positive impact on tourism entrepreneurial growth, with entrepreneurs experiencing revenue growth, employment growth, and profitability. The findings have implications for tourism entrepreneurs, policymakers, and educators, emphasizing the need for skill development programs and prioritizing skill development to drive tourism business growth. Overall, this review highlights the crucial role of skill development in driving tourism entrepreneurial innovation and growth, and provides valuable insights for stakeholders to support tourism entrepreneurial success.

Keywords: Skill development, entrepreneurial innovation, tourism business growth, tourism entrepreneurship, human capital



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INTRODUCTION

The tourism industry is a significant contributor to the global economy, accounting for approximately 10% of global GDP and employment (UNWTO, 2020). However, the industry faces numerous challenges, including intense competition, changing consumer preferences, and the need for sustainable practices (Hall, 2019). To address these challenges, tourism entrepreneurs must develop the necessary skills to drive innovation and growth (Hjalager, 2020). Skill development is essential for entrepreneurial success in tourism, as it enables individuals to identify opportunities, develop innovative products and services, and adapt to changing market conditions. Furthermore, skill development can enhance the competitiveness of tourism businesses, leading to increased innovation and growth. Tourism entrepreneurship plays a vital role in driving economic growth, innovation, and job creation (Acs & Audretsch, 2003). As such, understanding the factors that contribute to entrepreneurial success in tourism is crucial for policymakers, educators, and entrepreneurs themselves. Innovation and growth are critical outcomes of entrepreneurial success (OECD, 2005). Tourism entrepreneurs who develop innovative products, services, and processes are better positioned to compete in the market and achieve growth (Damanpour, 1991). Therefore, understanding how skill development impacts innovation and growth is essential for promoting entrepreneurial success in tourism. Despite the importance of skill development for entrepreneurial success, there is a lack of systematic reviews examining the impact of skill development on innovation and growth in the tourism industry. This systematic review aims to address this gap by examining the impact of skill development on innovation and growth in tourism entrepreneurship, and aims to provide a comprehensive understanding of the relationship between skill development and entrepreneurial success.

Objectives

1. To systematically review the literature on tourism entrepreneurship and skill development, examining their impact on innovation and growth.
2. To identify the key skills required for success in tourism entrepreneurship, and their role in driving innovation and growth.
3. To examine the relationship between skill development and entrepreneurial innovation and growth in the tourism industry, highlighting best practices and areas for improvement.

RESEARCH METHODOLOGY

This systematic review employed a comprehensive literature search strategy to identify relevant studies examining the impact of skill development on entrepreneurial innovation and growth in tourism industry. The search was limited to peer-reviewed articles, academic journals, books, and book chapters published in English between 2010 and 2022. Empirical research and conceptual papers that focused on tourism entrepreneurship and skill development were also included.

Theoretical Framework

The theoretical framework of this systematic review consists of three key theories: Human Capital Theory, Entrepreneurial Learning Theory, and Innovation Capital Theory. These theories provide a foundation for understanding the relationship between skill development and entrepreneurial innovation and growth in the tourism industry.

Human Capital Theory (Becker, 1964)

Human Capital Theory posits that education and training are essential for enhancing productivity and economic growth in the tourism sector. According to Becker (1964), human capital refers to the knowledge, skills, and experience that tourism entrepreneurs possess, which can be invested in to improve productivity and earnings in tourism ventures. In the context of tourism entrepreneurship, human capital theory suggests that tourism



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entrepreneurs' skills and knowledge are critical for their success in developing innovative tourism products, services, and experiences.

Entrepreneurial Learning Theory (Cope, 2005)

Entrepreneurial Learning Theory emphasizes the importance of learning and skill development in entrepreneurial success. Cope (2005) argues that entrepreneurs learn through experience, experimentation, and reflection, enabling them to navigate the complex and dynamic tourism industry. This theory suggests that tourism entrepreneurs' ability to learn and adapt is crucial for capitalizing on emerging trends, embracing innovation, and responding to changing tourist demands.

Innovation Capital Theory (Acs et al., 2017)

Innovation Capital Theory highlights the role of innovation in driving economic growth and competitiveness. Acs et al. (2017) argue that innovation capital refers to the knowledge, skills, and experience that enable firms to innovate and adapt to changing environments. In the context of tourism entrepreneurship, innovation capital theory suggests that entrepreneurs' ability to innovate and adapt is critical for their success in developing new tourism products, services, and experiences. According to the theory, innovation capital is composed of three main elements: human capital (the skills and expertise of employees), social capital (the networks and relationships that facilitate knowledge sharing), and intellectual capital (the patents, trademarks, and copyrights that protect intellectual property).

Key Skills for Tourism Entrepreneurial Success

Tourism entrepreneurship is a complex and multifaceted pursuit that requires a diverse set of skills to succeed (Kirzner, 1997). These skills are essential for navigating the challenges of starting and growing a tourism business, from developing innovative products and services to managing teams and adapting to changing tourist demands and market conditions. The four key skill areas that are critical for tourism entrepreneurial success are given below:

Technical Skills

Technical skills are the foundation of any successful entrepreneurial venture. These skills refer to the industry-specific knowledge and expertise required to start and run a business. For instance, a tourism entrepreneur operating a travel agency needs to possess strong knowledge of destination management, tour operations, and travel regulations. Technical skills enable tourism entrepreneurs to innovate, develop new tourism products and services, and solve complex problems, giving them a competitive edge in the tourism industry.

Business Skills

Business skills are essential for tourism entrepreneurs to manage and grow their tourism businesses. These skills include finance and accounting, marketing and sales, management and leadership, strategy and planning, and operations and logistics. Tourism entrepreneurs with strong business skills can create comprehensive business plans, secure funding, manage teams, and make informed decisions to drive growth and profitability in the tourism industry.

Soft Skills

Soft skills are personal attributes and personality traits that enable tourism entrepreneurs to interact and communicate effectively with others in the tourism industry. These skills include communication and presentation, teamwork and collaboration, leadership and motivation, time management and organization, adaptability and resilience. Tourism entrepreneurs with strong soft skills can build strong relationships with tourists, partners, and team members, navigate conflicts, and adapt to changing tourist demands and market conditions.

Digital Literacy Skills

Lastly, digital literacy skills are crucial in today's technology-driven tourism industry. These skills refer to the ability to effectively use digital tools and technologies to manage and grow a tourism business. Tourism entrepreneurs with



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strong digital literacy skills can leverage technology to streamline operations, reach new tourists, and drive innovation in tourism products and services.

Impact of Skill Development on Tourism Entrepreneurial Innovation

The impact of skill development on tourism entrepreneurial innovation is profound and far-reaching. As tourism entrepreneurs develop their skills, they become more adept at identifying opportunities, generating ideas, and turning those ideas into reality (Becker, 1964). This, in turn, leads to increased innovation, competitiveness, and growth in the tourism industry. Skill development enhances tourism entrepreneurial innovation by improving the ability to recognize and capitalize on opportunities. Tourism entrepreneurs with advanced skills are better equipped to analyze tourism market trends, identify gaps, and develop innovative tourism products and services.

Moreover, skill development fosters a culture of experimentation and risk-taking, essential for innovation in tourism. Tourism entrepreneurs who continuously develop their skills are more likely to experiment with new approaches, technologies, and business models, leading to the discovery of new tourism opportunities and the development of innovative tourism solutions. Furthermore, skill development enables tourism entrepreneurs to build and lead high-performing teams (Goleman, 2000). Additionally, skill development facilitates collaboration and partnerships in tourism. Tourism entrepreneurs with advanced skills can effectively communicate and collaborate with stakeholders, including investors, partners, and customers, leading to the development of new tourism ideas, access to resources, and increased innovation. Skill development is a critical driver of tourism entrepreneurial innovation. By investing in skill development, tourism entrepreneurs can enhance their ability to innovate, compete, and grow in the tourism industry.

Impact of Skill Development on Tourism Entrepreneurial Growth

The impact of skill development on entrepreneurial growth is significant, leading to increased revenue, employment, and competitiveness in the tourism industry. As entrepreneurs develop their skills, they become more effective at managing and growing their tourism businesses. Advanced skills enable entrepreneurs to:

- Identify new tourism business opportunities, expanding their market reach and revenue streams. With improved market analysis and strategic planning skills, tourism entrepreneurs can capitalize on emerging tourism trends and customer needs.
- Enhance operational efficiency, streamlining processes and improving productivity in tourism operations. By developing skills in areas like project management and supply chain optimization, tourism entrepreneurs can reduce costs and improve overall performance.
- Build and lead high-performing teams, driving innovation and growth in tourism. Tourism entrepreneurs with advanced leadership and management skills can attract, motivate, and retain top talent, fostering a culture of innovation and collaboration.
- Improve financial management, securing funding and managing cash flow effectively in tourism ventures. With advanced financial skills, tourism entrepreneurs can navigate funding options, manage risk, and maintain a healthy financial foundation (Ross et al., 2019).
- Develop strategic partnerships and collaborations, expanding their network and access to resources in the tourism industry. Tourism entrepreneurs with advanced communication and negotiation skills can build strong relationships with partners, investors, and customers.
- Adapt to changing tourism market conditions, pivoting their tourism business or approach as needed. With advanced skills in areas like market analysis and strategic planning, tourism entrepreneurs can stay ahead of the competition and navigate uncertainty.

Findings

This systematic review of the literature on skill development and tourism entrepreneurial success reveals a number of key findings that highlight the critical role of skill development in achieving innovation and growth in the tourism industry. The following points summarize the main findings of the review, providing insights into the impact of skill development on entrepreneurial success and the specific skills that are most critical for tourism entrepreneurs to develop.



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Skill development has a significant positive impact on entrepreneurial success, with a moderate to strong correlation between skill development and innovation and growth in the tourism industry.

The most critical skills for entrepreneurial success are:

- Strategic planning and management
- Leadership and team management
- Market analysis and understanding
- Financial management and planning
- Digital literacy and technology adoption

Entrepreneurs who invest in skill development are more likely to:

- Identify and capitalize on new tourism business opportunities
- Develop innovative products and services
- Improve operational efficiency and productivity in tourism operations
- Build and lead high-performing teams
- Secure funding and manage risk

Skill development has a positive impact on entrepreneurial resilience, enabling entrepreneurs to better navigate uncertainty and adversity. The impact of skill development on entrepreneurial success is influenced by the quality and effectiveness of the skill development program or initiative. Entrepreneurs who develop skills in areas such as sustainability and social responsibility are more likely to achieve long-term success and growth. Skill development has a positive impact on entrepreneurial networks and relationships, enabling entrepreneurs to build stronger connections with customers, partners, and investors. The impact of skill development on entrepreneurial success varies across different stages of the entrepreneurial journey, with different skills being more critical at different stages. Skill development programs and initiatives should prioritize the development of soft skills, such as communication and teamwork, in addition to technical skills relevant to the tourism industry. The impact of skill development on entrepreneurial success is influenced by the entrepreneur's ability to apply and implement the skills developed.

DISCUSSION

The systematic review of existing literature reveals a significant positive impact of skill development on tourism entrepreneurial success, particularly in terms of innovation and growth. The findings suggest that tourism entrepreneurs who invest in skill development are more likely to achieve sustainable growth, innovate, and stay ahead of the competition. The review highlights the importance of skill development in enabling entrepreneurs to identify and capitalize on new tourism business opportunities. By developing skills in areas such as market analysis and strategic planning, entrepreneurs can better understand their customers' needs and develop innovative tourism products and services to meet those needs. Moreover, the review emphasizes the role of skill development in enhancing operational efficiency and productivity in tourism operations. The findings also suggest that skill development is critical for building and leading high-performing teams. Entrepreneurs who develop leadership and management skills can attract, motivate, and retain top talent, fostering a culture of innovation and collaboration. The findings of this review have important implications for entrepreneurs, policymakers, and educators. Entrepreneurs should prioritize skill development as a key strategy for achieving sustainable growth and innovation. Policymakers should invest in programs and initiatives that support skill development for tourism entrepreneurs, particularly in areas such as digital literacy and leadership. Educators should integrate entrepreneurship education with skill development, ensuring that entrepreneurs have the skills needed to succeed. Overall, this systematic review provides a comprehensive overview of the impact of skill development on tourism entrepreneurial success, highlighting the importance of skill development for innovation and growth in the tourism industry. By prioritizing skill development, entrepreneurs can achieve sustainable success and drive economic growth.





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CONCLUSION

In conclusion, the systematic review of the literature on skill development and tourism entrepreneurial success highlights the critical role of skill development in achieving innovation and growth. The findings of this review emphasize the importance of entrepreneurs developing a range of skills, including strategic planning, leadership, market analysis, financial management, and digital literacy. By investing in skill development, entrepreneurs can gain a competitive edge, foster innovation, and achieve sustainable growth in the tourism sector. Moreover, the review reveals that skill development has a positive impact on entrepreneurial success, with entrepreneurs who invest in skill development more likely to achieve sustainable growth, innovate, and stay ahead of the competition. Hence, the evidence suggests that skill development is a critical component of entrepreneurial success. By prioritizing skill development, entrepreneurs can achieve their goals, drive innovation, and create a brighter future for their businesses. As such, it is essential for entrepreneurs, policymakers, and educators to work together to create a supportive ecosystem that fosters skill development and entrepreneurial growth which can unlock the full potential of entrepreneurs and drive economic growth and prosperity.

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Comparative study of the Start-Up Ecosystem - Karnataka and Andaman-Nicobar Islands

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ABSTRACT

The study lays emphasis on start-ups and how the Ease of Doing parameters play a role in understanding the start-up culture in a region. The study also tries to bring forth the start-up scenario post-pandemic and the challenges faced by start-ups during the same period. The study, therefore, focuses on Karnataka (State) and Andaman and Nicobar Islands (Union Territory). The preliminary observation of factors affecting the start-up culture in both regions are considered for the study. The tools used in the treatment of the data gathered are regression analysis and chi-square analysis. Graphs and appropriate statistical tools have been taken help of for interpretation and inferences to be drawn.

Keywords: Start-ups, Ease of Doing Business, Revenue, Karnataka, Andaman and Nicobar Islands.

INTRODUCTION

The ecosystem for infant companies in India has been eventful due to changing dynamics in investor sentiments, government policies, and the overall regulatory atmosphere that has undergone major overhauling in the last few years. The startup culture has matured in while also highlighting shortcomings and achievements on this front. Government intervention through its policy framework has led to the development of startups and encouragement to entrepreneurs in the country, which include Make in India, Digital India, and Startup India. Recognizing the changing requirements of a dynamic ecosystem, the State/UT Startup Ranking Framework 2019 was developed. The framework also considers lessons learned and comments received from prior ranking efforts. States and UTs are divided into categories X and Y: States and UTs have been separated into Category-X and Category-Y to maintain uniformity and assure standardization in the ranking process. Category X (This group has all States and UTs except those in Category 'Y')



**Top Performers - Karnataka, Kerala**

Category Y (This group has all North-Eastern States except Assam and all UTs except Delhi.)

Best Performer - Andaman and Nicobar Islands

Ease of Doing Business – and what the rankings indicate

The World Bank's Ease of Doing Business rankings offer an unbiased evaluation of business ease pertaining to rules of 190 nations while ranking them across the ten parameter criteria. India improved its overall ranking by 53 spots over a period of two years and by 65 spots over the course of four years, recording a rise of 23 ranks in 2018 after making a notable gain of 30 positions in 2017. It is significant that, despite regulatory hurdles, important areas including cross-border trade, building permits, starting a business, and obtaining financing and power have improved.

REVIEW OF LITERATURE

- Chatterjee, Deepashree. (2020). Startup India. This paper briefly discusses the various action plans and schemes which the government has initiated through the scheme of Start-up India.
- Bhalerao, Vaibhav & Harshal, Dayma. (2020). A Comparative Study of the Indian and the American Start-up Ecosystem.
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Observations from the ROL-

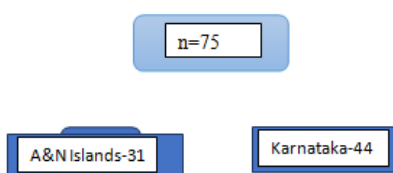
Most research papers analyze the existing startup culture and ecosystems in India with a primary focus on Government initiatives like Make in India and Startup India. Many research papers analyze the life cycle of startups. However, this study focuses on the factors affecting the startup culture with a focus on Karnataka and Andaman-Nicobar Islands using primary data.

Objectives of the study

- To determine the significance of the parameters of EODB in both the regions (Karnataka and A&N Islands)
- To analyze the challenges faced by startups during the covid-19 pandemic in Karnataka and Andaman and Nicobar Islands

METHODOLOGY

The study is both analytical and descriptive and relies on primary data. Field data has been mobilised through a structured questionnaire from startups operating from Karnataka and Andaman and Nicobar Islands. The questionnaire was curated in a manner that the necessary variables as per the requirement of study objectives was reached out. The study mainly focuses on how the startups have evolved and the key determinants inducing the working of small businesses in both regions. For the primary data requirement, purposive sampling under the Non-probability sampling technique was used, where the sample magnitude is 75. The tests conducted for the data collected are as follows. For Primary data – Regression analysis and Chi-Square test.



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RESULTS AND DISCUSSIONS

To ascertain the significance of the parameters of ease of doing business in both the regions (Karnataka and A&N Islands).

- To assimilate the factors and the parameters conducive for the startups in Karnataka and Andaman and Nicobar Islands
- To analyze the challenges faced by start ups in Karnataka and Andaman and Nicobar Islands during the Covid-19 pandemic. A primary survey was administered considering a sample extent of 75, of which 44 responses were recorded from Karnataka and 31 responses were recorded from Andaman and Nicobar Islands using purposive sampling technique under non-random sampling; following which the discussion is presented thereafter-

OBJECTIVE 1 ANALYSIS

Regression analysis on Ease of Doing parameters between Karnataka and Andaman and Nicobar Islands The below mentioned statistical tests were conducted across 5 EODB parameters in Karnataka and the A&N Islands. The parameters under focus are ranked by start-ups on a Likert scale of 1-5, 1 being very difficult and 5 being very easy. The independent variable for the test is the demographic variable – location i.e., Karnataka/A&N Islands. The ordinal regression test is run to predict the ordinal value of Ease of Doing business on an independent variable-the location of the start-up.

Regression Analysis

General hypotheses

Model fitting

H₀- There is no significant difference between the location and the Ease of Doing Business parameter(s)

H₁- There is a significant difference between the location and the Ease of Doing Business parameter(s)

Goodness-of-Fit

H₀- the observed parameter has goodness of fit with the variable- location

H₁- the observed parameter does not have goodness of fit with the variable- location

Pseudo R-Square

A value greater than or equal to 0.7 signifies that the variance between the variables has been explained

PARAMETER 1-Starting a business

INFERENCE

Since the p value is greater than 0.05, there is no significant difference between location and starting a business, signifying that the location does not contribute to influencing one to start a business. It is the same across both Karnataka and Andaman. The p-value is greater than 0.05, indicating a significance between the location and starting a business. The goodness of fit analysis, the population is skewed. Survey entails that, majority of the enterprises tend to find starting a business in their respective locations easy. The R-Square value is less than 0.7 which shows that a very low degree of variance has been explained in the model. Only 1% of the model is explained, stating that it is an unreliable mode.

PARAMETER 2 - Registering property

INFERENCE

The p-value is less than 0.05, indicating the significance between location and registering a property for business. Location influences the property registration decision and process. According to the survey conducted, it is easier for start-ups to register their property in Karnataka when put in comparison to Andaman. Since the p-value is greater than 0.05, there is no significance between location and registering property under the model of good fit test signifying that the distribution is not skewed, as the start-ups in Karnataka find registration of property easy, on the other hand, start-ups in Andaman find registration of property difficult. The R-Square value is more than 0.7 which



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shows a high degree of variance has been explained in the model. 70% of the model has been explained, stating that this is a reliable/ good model.

Parameter 3: Dealing with Construction Permits**INFERENCE**

the P value is less than 0.05, which signifies that there is a difference between location and pertaining to construction permits. Location influences the procedure with regard to construction permits. It is comparatively easier for start-ups to acquire construction permits in Karnataka when compared to Andaman. Since the p-value is greater than 0.05, there is no significance between location and dealing with construction permits under the goodness of fit test. This signifies that the distribution is not skewed, as the start-ups in Karnataka find dealing with construction purposes considerably easy than Andaman. The R-Square value is more than 0.7 which shows a high degree of variance has been explained in the model. 80% of the model is being explained that this is a reliable model.

PARAMETER 4 - Getting Electricity**INFERENCE**

The P value is less than 0.05, which signifies that there is a significance between location and getting electricity. Location influences the start-up in ease of getting electricity. According to the survey conducted, it is very easy for start-ups to get an electricity connection in Karnataka when compared to Andaman. Since the p-value is greater than 0.05, there is no significance between location and ease of getting electricity under the goodness of fit test. This signifies that the distribution is not skewed, as the start-ups in Karnataka find getting an electricity connection easy, and on the other hand start-ups in Andaman find it very difficult to get an electricity connection. The R-Square value is less than 0.7 which shows a high degree of variance has been explained in the model. 70% of the model is being explained which states that the model is reliable.

PARAMETER 5 - Getting Credit**INFERENCE**

The P value is greater than 0.05, this signifies that there is no significance between location and getting credit. This means that the location does not influence start-ups in the ease of getting credit. This means that irrespective of the location the start-ups find it easy to get credit to start their business. The P value is greater than 0.05, which means that there is a significance between the location and ease of getting credit. Therefore, according to the goodness of fit analysis, the population is skewed. Both populations tends to find it easy in getting credit to start their business in both locations (Andaman and Karnataka). The R-Square value is less than 0.7 which shows a less degree of variance has been explained in the model. Only 30% of the model is being explained, therefore it is an unreliable model.

OBJECTIVE 2

To analyze the challenges faced by startups during the covid-19 pandemic in Karnataka and Andaman and Nicobar Islands

CHI-SQUARE TEST

H₀- there is no relationship between startups operating online and the challenges(s) faced by startups during Covid-19

H₁- there is a relationship between startups operating online and the challenges(s) faced by startups during Covid-19
Challenges – 1) Lack of funds 2) Temporary shutdown of business 3) Loss of customers

INFERENCE:

Lack of funds: Karnataka - Since the P value is less than 0.05, there is a significant association between the 2 variables. This means lack of funds influences the decision pertaining to whether the startups would want to operate online or not. Andaman - Since the P value is less than 0.05, there is a significant association between the 2 variables. This means lack of funds influences the decision pertaining to whether the startups would want to operate online or not.



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There exists a greater association between the 2 variables in Andaman 0.010<0.069. Therefore, H₀ is rejected for both regions. Temporary shutdown of business: Karnataka - Since the P value is less than 0.05, there is a significant association between the 2 variables. This means the temporary shutdown of a business due to covid- 19 influences the decision pertaining to whether the startups would want to operate online or not. Andaman –As noted, the P value is less than 0.05, there is a significant association between the 2 variables. This is because a large number of startups in Karnataka operate in both Physical and online modes of business even prior to Covid – 19 Pandemic, whereas startups operating in Andaman did not have an online mode of business prior to the pandemic. Therefore, the null hypothesis is rejected for both regions Loss of customers :Karnataka - Since the P value is greater than 0.05, there is no significant association between the 2 variables. This means that the loss of customers due to covid- 19 does not influence the decision pertaining to whether the startups would want to operate online or not. Andaman - Since the P value is greater than 0.05, there is no significant association between the 2 variables. This means that the loss of customers due to covid- 19 does not influence the decision pertaining to whether the startups would want to operate online or not. Therefore, the null hypothesis is failed to be rejected.

CONCLUSION

To analyze the factors and parameters conducive to startup culture in A&N islands and Karnataka Ordinal regression using the logit model showed that the location of the startup has a significant influence on the parameters of registering property, regarding construction licenses and getting credit. To analyze the challenges faced by startups in Karnataka and Andaman and Nicobar Islands and the factors affecting them. There was a significant relationship between startups operating in Karnataka with only physical business platforms and the challenges faced by these startups namely, lack of funds, temporary shutdown of business, and loss of customers. However, startups operating only in the physical business workspace in Andaman and Nicobar Islands showed a significant relationship with the challenge of a temporary shutdown of the business. Compared to Karnataka, Andaman and Nicobar Islands still has a lot of areas to work on. The business opportunities in Andaman and Nicobar Islands often do not turn out to be successful as the union territory is classified as defense land under the Government of India. Therefore, because of extremely strict rules and regulations regarding the registration of property and construction permits, there is a discouragement of financial investments made by private players from mainland India. With the onset of improved internet services in the islands, there can be more expectations of digitization of the market in Andaman and Nicobar Islands which will cause an expansion in the market and hence increase the coverage area of the market. Commuting is another major issue regarding trade in the islands, goods are imported and exported through waterways and airways. Improvement in the connectivity of the union territory to the mainland can improve trade and open ways for new businesses to operate from the islands. The Administration of Andaman and Nicobar Islands should work towards simplification of rules and regulations regarding the registration of property and dealing with construction permits. The Government of India should come up with policies that provide subsidies to young entrepreneurs to encourage and develop the startup ecosystem in Andaman and Nicobar Islands. Work towards creating awareness amongst the people in Andaman and Nicobar Islands regarding existing Government initiated schemes and policies which are mainly channelized towards enhancing the entrepreneurial ecosystem like Startup India, Make in India, etc. The Karnataka State authority can interfere towards creating incubation cells and support centers that support the existing startups and the new startups as there has been a tremendous surge in the number of state's startups. More policies that provide subsidies to entrepreneurial projects that are working towards environmental sustainability to maintain ecological balance.

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Table 1 : Summary Table and Hypothesis Interpretation

Name of Test	Significance Value	Association Inference	Hypothesis Interpretation
Model Fit	0.253	> 0.05	The null hypothesis failed to be rejected
Goodness of Fit	0.193	> 0.05	Null Hypothesis is Rejected.
R Square	0.184	< 0.7	10% of the model is explained.

Table 2 : Summary Table and Hypothesis Interpretation

Name of Test	Significance Value	Association Inference	Hypothesis Interpretation
Model Fit	0.019	<0.05	Null Hypothesis is rejected
Goodness of Fit	0.314	> 0.05	Null Hypothesis is failed to be rejected.
R Square	0.775	> 0.7	70 % of the model is explained.

Table 3: Summary Table and Hypothesis Interpretation

Name of Test	Significance Value	Association Inference	Hypothesis Interpretation
Model Fit	0.014	< 0.05	Null Hypothesis is rejected
Goodness of Fit	0.145	> 0.05	The null Hypothesis is failed to be Rejected.
R Square	0.81	> 0.7	80 % of the model is explained.

Table 4: Summary Table and Hypothesis Interpretation

Name of Test	Significance Value	Association Inference	Hypothesis Interpretation
Model Fit	0.031	< 0.05	Null Hypothesis is rejected
Goodness of Fit	0.172	> 0.05	Null Hypothesis is failed to be Rejected.
R Square	0.71	> 0.7	70 % of model is explained.

Table 5: Summary Table and Hypothesis Interpretation

Name of Test	Significance Value	Association Inference	Hypothesis Interpretation
Model Fit	0.088	> 0.05	Null Hypothesis is failed to be rejected
Goodness of Fit	0.065	> 0.05	Null Hypothesis is Rejected.
R Square	0.374	< 0.7	30 % of model is explained.

Table 6: Chi-square test between the Startups operating in online mode and the challenges faced

	Kamataka		A& N Islands	
	Value	Asymptotic Significance (2-sided)	Value	Asymptotic Significance(2-sided)
Lack of funds	6.718	.069	4.034 ^a	.010
Temporary shutdown of business	7.218 ^a	.040	7.034 ^a	.011
Loss of customers	6.369 ^a	.341	3.171 ^a	.205





Medimix: A 50-Year Journey of Entrepreneurial Innovation and Brand Leadership in Ayurveda Personal Care

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ABSTRACT

Today, wellness is a serious business around the globe as many companies try to create their fortunes in the industry. Given the modern lifestyle induced health issues, customers have started paying more attention to wellness solutions. While a growing economy and populous country like India offers significant market potential for niche products, there is also a shift to age-old practices of Ayurveda as a mainstream care for health issues. Among the many natural approaches to health and wellness, the Indian Ayurveda has retained its charm and impact in a competitive wellness market. Leading domestic player Medimix is synonymous with Ayurveda. The brand Medimix has carved a niche for itself in the personal care segment with its dual approach of preserving ayurvedic traditions and tweaking its media campaigns to changing consumer landscape. The company turned to nature for business idea, conceptualised and pioneered ayurveda based soap at a time when Ayurveda did not receive much recognition in business forums. Part I of the case illustrates entrepreneurship outlook for launching new business and explores various dimensions of entrepreneurship deployed by the company linking it with an appropriate theoretical framework. Part II of the case explores the brand journey of Medimix with focus on brand positioning through various initiatives for 50+ years. The case is developed through an in-depth secondary data reference. Overall, the case would help readers identify essential pivots and growth levers that brand Medimix adopted to unlock value in a highly competitive market. The case calls for crafting new marketing plans to sustain leadership in the Ayurveda market for personal care products. The case can be used for courses of entrepreneurship, marketing management and branding of both under graduate and post graduate management programs. The students are expected to have knowledge of marketing fundamentals.

Keywords: Ayurveda, FMCG, Entrepreneurship, Strategy, Brand Positioning, D2C



**Rajalakshmi Vel and Poornima****INTRODUCTION****Saga of Medimix**

It was 7 p.m in the evening, a hot humid day for Chennai. Dr V.P. Sidhan (Dr.Sidhan) a well-known doctor of Indian railways returned to his quarters engulfed in thoughts. Sowbhagyam Sidhan, the dutiful wife, probed his deep silence with a bright smile and evening coffee. 'I come across our railway labourers who face skin ailments on a recurring basis. Other than medicines, I prescribe ayurvedic oils. My friends advise me to try my formulations and develop a soap' shared Dr.Sidhan. The wife jokingly remarked 'a soap for multiple skin disorders... that would be sheer magic.' The idea of developing an ayurvedic soap bar that could solve multiple skin problems originated. Hailing from a family of ayurvedic practitioners, Dr.Sidhan tried his hand at various formulations. The couple invested their limited salary to make soaps in the kitchen. They were assisted by Ashokan, the first employee of Medimix. No boardroom discussion, no market research, no feasibility study. A pure conviction backed by sound knowledge was what made Dr.Sidhan start his entrepreneurial journey in 1967. During the initial years, the soaps were made by Dr Sidhan himself in the backyard of the railway quarters assisted by his wife who did cutting, pressing and packing. In a day they made anywhere between 100-120 soaps, which were pedalled to medical shops by Dr.Sidhan. Over the years as the soap gained popularity, they rented a house for scaling up production. The quality of the soap to heal skin diseases spread by word of mouth. Doctors recommended it to their clients and Medimix entered the physician's prescription list. 50+ years later, as the company is acing to be No.1 in Ayurveda personal care segment, the second generation leader Mr.Pradeep Cholayil is confronted with newer challenges.

Genesis of Medimix

The visionary doctor with his sharp business acumen commercially launched brand 'Medimix' a name coined from the words Medicine and Mix thereby marking the journey of a prescription-only product to a most-sought after brand. Dr.Sidhan's khadi-enterprise set up its first manufacturing unit with one employee and registered as Cholayil Private Limited²⁰. Medimix, an atypical soap was an amalgamation of 18 herbs²blended with three natural oils that protect and nourish skin in the most natural way. Over the years, though many product categories were added, the brand kept its essence intact i.e Herbal and Handcrafted.

The grandmother swore for its ayurvedic properties

The father enjoyed its fragrance

The mother acknowledged its skin care

The neighbour found value for money

All by a home-grown brand that gave legacy brands a run for their money!

As business evolved challenges arose. Medmix faced its first labour strike at its Chennai plant in 1980s that halted production¹². Dr Sidhan roped in A V Anoop from his family to handle the managerial issues at the plant. Work resumed to normalcy in the plant with adding of one more production unit in Madhavaram, Chennai¹².

Excellence of Brand Medimix

- Pioneer in Ayurveda

The brand had a compelling story to tell. Back in 1900s, Cholayil Kunju Maami Vaidyar, a physician by profession advocated natural and unconventional methods of healing. The family had an oil that was prescribed for all kinds of skin ailments. His contributions earned him the titles Modern Dhanvantri, Miracle Man for medicinal cure. He travelled extensively to other parts of the country and Sri Lanka treating patients. As a tribute to his proficiency, his earnest patient Shri Narayan Guru remarked,

"There are no numbers that can't be divided by one

There are diseases that can't be cured by maami"

Source: www.cholayil.com





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The legacy was carried on by his son Shri Sankaran Vaidyan who exhibited the same proficiency in treatment. Further he helped the financially weak by providing free treatment and medicines. In line with the family wisdom, Dr Sidhan, being a clinically efficient physician combined various ayurvedic formulations for treating patients. He pursued extensive Ayurveda research and Medimix is a testimony to his in-depth knowledge of Ayurveda for economic benefit.

- Handmade

A brand that dates back to half century ago, Medimix soap bars are meticulously made by hand till date, preserving its tradition of 'handmade'. The label 'Medimix' on soap bars is engraved with a hand operated machine. As the conveyor belt takes the soaps to the packaging line, employees do the final packaging by hands. On an average each 8 hour shift produces 1,00,000 soap bars every single day⁹. The sales numbers are pretty impressive that touched the 10,000 ton mark for FY 2019⁹ for the first time in its 50 year long history.

- Process Superiority

According to company sources, unlike most soap manufacturers who use soap pellets that are by-products of oil refineries, Medimix blends the oils directly in the soap making process. To this rich mixture, herbal extracts and perfumes are added at regular intervals, stirred and rotated in huge stainless steel containers causing the aroma to infiltrate the senses. Froths rise to the brim with organised stirring which are eventually laid out on the turntable. Shades of green emerge in varying textures indicating the final time it was stirred. Overall, an optimum proportion of coconut oil mixed with herbs ensures the retention of natural skin glycerine.

"This is why Medimix remains the largest selling handmade soap in the country. At every stage, we've got people operating these machines," states Vinayachandran, VP of AVA group¹².

- Innovation

At a time when the industry was dominated by large players who had automated processes for soap making, the company relied on human interventions at every stage of its production process. The company adopted innovative practices wherein redesigned some aspects of the machinery as suggested by employees. Process innovation was carried out to ensure safety protocols.

Medimix is not only known by what goes into it, but also by what goes behind making this Ayurvedic soap a force to be reckoned with in a market dominated by multinational players. The process does not use any electricity, but relies on a series of innovations made by the labourers involved, which makes it seamless and cost-effective²⁰.

- Employees First

It was a general opinion that scaling up is not possible without use of electricity operated machines. The company regularly solicited ideas from each employee as it strongly believed 'the one who makes the soaps knows better'²⁰. Ideas are screened by an in-house team of experts and once validated, further trials are conducted for implementation. Funds are exclusively allocated for the innovation and experimentation. Unlike, companies who hire the services of external consultants, Medimix turned back to its employees for idea generation.

- Cost Advantage

Handmade soaps involve labour intensive production process. As a result, it consumes less electricity, resulting in savings for the brand. The benefit is passed on to consumers in the form of reduced price. As per 2018 company reports, approximately 800-900 tonnes of soaps were produced per month priced anywhere between Rs.15 – 50 (as per weight)¹². By not taking the mechanized route, the company remains true to its legacy of handcrafted and herbal and is able to offer the soaps at a competitive price.





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Division of Business

The year 2007 saw the split in business operations. Today, the brand name Medimix is shared by two companies, AVA, in the South owned by Dr.Sidhan's Son-in-law A V Anoop and Cholayil in the north run by his son Pradeep Cholayil.

AVA Group

'The Coronavirus has changed the demand for the brand, creating a pull for the product, instead of relying on a push from the marketers.'⁷ AVA group has forayed into the hand-wash and sanitiser category, an opportunity thrown by pandemic. A V Anoop, MD, AVA group remarks "The growth came as sweet surprise for the segment, which was de-growing"⁷ registering a 25% surge in demand for liquid soaps. Marking the 50th year of operations, AVA group also forayed into healthcare segment by opening Sanjeevanam, a holistic health centre in Kochi, Kerala. The centre hosts an ayurvedic therapy unit, a beauty centre, restaurant and nature store. Further diversifications of the group include Kaytra that marks the foray of the brand into skin and hair care segment. The takeover of Melam Spices by AVA group marks its entry in food segment. While retaining its flagship product Medimix soap, in order to tap the beauty segment in personal care products the brand Divine was launched. Divine has six variants which are mostly overlaps; Turmeric and sandal, Clear Glycerine for deep hydration, for Oil balance, for Natural toning, Sandal soap and transparent soap. While it is clear that Medimix is handmade, no such specification is stated for other soap varieties.

Cholayil Private Limited

In North, the company Cholayilmarkets under the same brand name Medimix and the product portfolio consists of soaps with four variants; 18 Herbs, Natural Glycerine, Sandal and Turmeric and face washes with eight variants; anti pimple, anti tan, oil clear, everyday face scrub, moisturising, natural glow, turmeric and anti pimple. In the personal care category, it has Ayurvedic pharma products, Ayurvedic treatment and care services. Medimix, Cuticura and Krishna Thulasi are the three main brands that Cholayil has under its fast moving consumer goods (FMCG) business segment. As a part of digital strategy, Cholayil launched its own website. The brand has chosen direct-to-consumer (D2C) platform to cater to domestic and export market with diversified basket of personal care products. "The D2C business is helping us in generating lot of data and insights about who our real consumers are. Also, it gives us an opportunity to test out new products directly with consumers," notes MD & CEO, Pradeep Cholayil¹³. Given the challenges of a highly penetrated market, the company Cholayil has found an opportunity to grow its offerings to South-East Asian markets of Vietnam, Taiwan and Cambodia. The shift towards herbal-naturals across the globe is an opportunity the company is capitalising on. Buoyed by robust demand for Ayurveda products, Cholayil has unveiled its premium range Sadhev as an independent brand sold through D2C. Sadhev consists of body oils, serums, shampoos and premium soaps which would be eventually marketed through exclusive stores in top metros.

Journey of the brand from Print to Digital

It was the year 1969 and television was the privilege of the elite few in metros. Print media ruled the roost and advertising meant newspaper advertisement only. The soaps that were in vogue were mostly Lux, Rexona which promised beautiful skin to the young ladies and teenagers. Yet, Dr.Sidhan, from Tamilnadu, an allopathic doctor from the Indian railways embarked on providing skin care to sanitation workers launched the soap Medimix using ayurvedic preparation. 'Doctors prescribe Medimix' was their first tagline on print, OOH, and radio. But as early as 1970's they showed a bikini clad woman and launched the soap on the platform of ayurveda claiming cure of the most common skin ailments, pimples, blackheads and more serious diseases like scabbies. During the late 90s and early 2000s, Medimix moved from 'Cure for skin diseases proposition' to 'protection proposition'. The tag line was 'Asli Suraksha, Kudrati Suraksha' meaning natural protection is real protection. The audience for Medimix has been different and has extensively focused on the uniqueness of the product and endorsement by celebrities. 'Tvacha kal ke liye taiyaar' campaign, released in the late 90s, tried to brand Medimix for 'timeless beauty' hinting to the fact that disease free skin means timeless beauty. The next in line advertisement (ad) launched in early 2000 read 'Skin care





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today for better tomorrow'. This featured a mother and daughter duo signalling the transformation from Skin protection to Skin protection + Handing over to generations platform. Television grew in popularity in late 1980's and early 1990's. Medimix was quick to spot the opportunity and featured celebrities like actress Trisha. The television ad focused on branding Medimix as one stop solution for all skin issues with an underlying message that discouraged the use of pimple creams and other beauty products which were considered to be expensive thereby pushing Medimix to value for money platform to influence the price conscious customer. The 'Shut Up' series moved Medimix from Skin protection to Fun platform. In 2004, Medimix released Ms Pimple ad, brought forth the daily skincare problems faced by teenage girls. The fun tone connected well with teenagers and is one of the popular of Medimix series. It also said no to anti pimple lotions and creams sold in the market, thereby positioning Medimix as the ultimate solution aggressively endorsing the '18 herbs' real ayurvedic soap. As more ladies started to work, Medimix embarked on 'Sachchai Aur Suraksha' campaign that celebrating woman who took up tough roles. Designed to showcase the brand's tribute to women army personnel, the ad portrayed a defence woman holding rifle for war purpose. How strong women go with zero skincare by using Medimix underlining that 'Truth is protection'. Another campaign which set apart the soap from its competitors is 'Nothing better than natural'. The ad urged all generations, to chuck their gadgets and go natural.

Medimix in Digital Space

Early 2019 saw the brand again repositioning itself as 'Get skin fit with fast acting Ayurveda'. The medium was mostly digital. Taking advantage of the two way communication being possible in social media, the brand began to engage with young customers by asking their opinion through 'Time to rethink' campaign focused on breaking the myth that Ayurveda is slow and thus was born the 'Fast acting Ayurveda' campaign. The face book page of Medimix Ayurveda has about 2,80,000 people speaking about it. Social media has dual advantage; Firstly, it enables multinodal exchanges. Secondly, social media ads can be changed quickly responding to the mood of the audience. A special ad created for Valentine's Day showed Ayurveda as solution for a speed-date and quick results. Similarly, the Ganesha idol ad during Ganesh Chaturthi, drew the attention of the audience to environment pollution and urged them to use the Medimix bar instead ditching the traditional Ganesha murthi made of mud. The immersion of the idol then would be soap water which could then be used as hand wash. The brand echoed the principle of triple bottom line i.e Profits, People and Planet, the way ahead for modern businesses. The YouTube channel reinforces the campaign 'Get skin fit with Ayurveda' and consists of all commercials which are on TV. The brand has a strong presence in Instagram as well with the content focusing on the concept 'Get skin fit with Fast acting Ayurveda'. Medimix as a brand has come a long way since it first started its brand positioning as 'Soap recommended by doctors', 'Natural protection is the best protection', 'Value for money', 'Nothing better than natural'. In the post pandemic world, the brand has repositioned its strategy with the campaign 'Get skin fit with Ayurveda' insisting on good skin protection through Ayurveda. The brand has taken the celebrity endorsements route by roping in actresses Trisha, Vidya Balan and Parineeti Chopra.

Lead or Bleed

Back in the mid-2000s, a sense of peril gripped Pradeep Cholayil, the second generation leader. As the world evolved, new beauty conscious consumers arrived. It was time to revamp the brand; to ditch the red-black packaging. Dr. Sidhan didn't agree. There were reasons. He had worked hard to make the soap a household brand. Any changes may weaken the loyal customer base which he noticed in the case of other brands who changed packaging and lost significant market share. After much reasoning with his son he agreed and the brand had a complete makeover with a fresh green packaging, marking the move from medicinal bar to beauty soap. A decade later, the space in which the brand pioneered was cluttered with new players popping up each day communicating directly with the customers. Heading into 2019, the jubilee year of the brand, though the company clocked in Rs.200 crore revenue as a top selling brand, volumes were shrinking²². A consumer survey of 2019 carried out clearly pointed that mostly people used Medimix when they faced skin issues and there were few regular users¹⁵. This time around the company invested around 12-15% of overall sales on marketing¹⁶. It was time to change the narrative. It ran digital campaigns to appeal to new age consumers.



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'Young consumers feel that natural products take a lot of time in providing results, and there is a serious dearth of time and patience in their fast-paced life. Medimix has been repositioned to bust this myth with the new brand positioning,' said Ashish Ohlyan, Marketing Head, and Product Development, Medimix¹⁵. Actor Parineeti Chopra was chosen as the new brand ambassador to promote the ayurvedic offerings to young consumers. The tweaked advertising strategy helped to them improve average consumption and purchase occasions. According to Ohlyan, '..... We are continuously investing in revamping our brand image'¹¹. Other moves by the brand included sponsoring team Kolkatta Knight riders in IPL 2020, Search engine optimization (SEO) activities, partnering with e-commerce players Flipkart, Amazon, launch of own digital platform for D2H, deployment on customer analytics, all with a zeal to grow.

Mapping the road ahead

As the brand keeps working on its campaigns in a highly competitive market, the long-term objective of the brand is to evolve as a leader in Ayurveda, a space in which it pioneered 54 years ago. The brand is also transitioning as a personal care player and the sole mission of the company is: To be the go to product for all age groups – millennials to older generation. The challenges are different. The characteristics of the Ayurveda market have changed. It is abysmal flooded with new theories of Ayurveda created by brands. Not until recently, it began to be a part of wellness. People didn't consider herbal as something related to wellness. Just like how sports is regarded as wellness today. They thought both were separate until studies came to show that Ayurveda skin care is holistic leading to overall wellness. With this new found knowledge, consumers are increasingly curious to find out product ingredients i.e what exactly goes into the product they buy. There is a wave of consumer consciousness all industries are facing. Authenticity upholds their purchase decisions. As a result the loyal consumer base for brands keep oscillating. Additionally, there are things like online reviews, social media forums which influence what goes into their cart. How can an iconic brand like Medimix recalibrate authenticity to foster customer loyalty? What could be a well-crafted strategy that the company can aim at for long-term growth? While India is a big market for Ayurveda market for personal care products, there is no one uniform scenario within India. 'There is a stark difference between the scenarios in south and non-south market and there are rural markets within' says Jagdeep Kapoor, Chairman and MD at Samsika Marketing consultants²². Making inroads into state markets of Gujarat, Rajasthan, Maharashtra requires more than running regular regional commercial ads given regional cultures. These markets are also highly penetrated by Hindustan Unilever with its products such as Lux, Hamam and Rexona. What out of box approach can a 50-year brand adopt to gain wallet share first and market share gradually? How can Mr. Cholayil apply his experience of Medimix in Chennai to cater to new markets and eventually grow his new categories of body wash, shampoo, conditioners and premium products? 'We want to be more than a soap company!' exclaims the agile leader²².

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The Role of Education and Skill Development in Empowering Women and Boosting India's Economy

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ABSTRACT

Education and skill development are pivotal in empowering women and driving India's economic growth. This paper examines the transformative impact of education and skill development on women's empowerment and India's economy. It highlights the positive correlations between women's education, skill development, and economic outcomes, entrepreneurship, and GDP growth. The study also explores the challenges and barriers to women's education and skill development, such as gender bias, limited access to resources, and societal norms. To address these challenges, the paper recommends policy interventions, including gender-sensitive education and training programs, mentorship initiatives, and civil society. By investing in women's development, India can unlock its full economic potential, promote achieve sustainable development.

Keywords: Women empowerment, education, skill development, India, economic growth, gender equality, human capital development.

INTRODUCTION

India's economic growth and development are inextricably linked to the empowerment of its women. However, the country's progress is hindered by the underutilization of its female workforce. Education and skill development are essential catalysts for empowering women and unlocking their full potential. Despite significant advancements, Indian women continue to face numerous challenges, including:

- ❖ Limited access to quality education
- ❖ Gender-based discrimination





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- ❖ Limited career opportunities
- ❖ Social and cultural constraints

These barriers prevent women from participating fully in the economy, leading to a significant loss of talent, innovation, and productivity.

- ❖ Enhancing employability
- ❖ Increasing entrepreneurship
- ❖ Improving decision-making capabilities
- ❖ Boosting economic participation

This paper explores the transformative role of education and skill development in empowering women and driving India's economic growth. By examining the current state of women's education in India and the effective strategies for unlocking the full potential of Indian women and propelling the country towards sustainable development.

- Empower women: Enhance their decision-making capabilities, boost self-confidence, and foster economic independence.
- Reduce gender inequality: Narrow the gender gap in education, employment, and income.
- Stimulate economic growth: Increase labor force participation, boost productivity, and drive innovation.
- Improve social indicators: Enhance health, nutrition, and child welfare outcomes.

LITERATURE BACKGROUND

OBJECTIVES

1. To analyze the trends in women's empowerment indicators in India from 2005 to 2023.
2. To examine the relationship between economic growth and women's empowerment in India.
3. To identify the progress made in women's education, labor force participation, and leadership positions in India.
4. To highlight the gaps and challenges in achieving femininity fairness and women's empowerment in India.

RESEARCH METHODOLOGY

Study used for secondary data journals, statistical databases, and other published literature, reputable sources, such as: Government reports and statistical databases (e.g., Ministry of Human Resource Development, National Sample Survey Office), Academic journals and books (e.g., Journal of Education and Development, Indian Journal of Labour Economics), International organization reports (e.g., World Bank, International Labour Organization)

Period of the study

The study period spans from 2005 to 2023, covering 18 years of data and trends on women's education, skill development, and economic empowerment in India. Statistical tools

Arithmetic Mean and Average

$$\text{Mean} = \frac{\sum x}{N}$$

Where,

∑= Represents the summation

x = Represents Scores and

N= Represents number of scores





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Index Numbers

Index Number for the Year, I

$$= \frac{\text{Value of Education and skill development in the year } i}{\text{Value of Education and skill development in the year}} \times 100$$

RESULTS AND DISCUSSIONS

Women's Education

This table highlights the progress made in women's education and empowerment in India from 2005 to 2023. The indicators show a consistent increase in the average values indicate a steady improvement in women's education and empowerment, with significant progress in literacy rates, primary education enrollment, and higher education enrollment. The projected values for 2023 suggest a continued positive trend, indicating and women's empowerment in India. This table presents the trends in women's education and empowerment indicators in India from 2005 to 2023. The indicators include; Female Literacy Rate (%), Girls' Enrollment in Primary Education (%) Women's Higher Education Enrollment (%) from 2005 to 2022 and projected values for 2023 for the actual value. The 2005 as the base year (100%) in Index number is used. Female Literacy Rate: There has been a steady increase in female literacy rate from 54.2% in 2005 to 67.25% in 2023 (projected). Average literacy rate is 62.45%, Girls' Enrollment in Primary Education: There has been a consistent increase in girls' enrollment in primary education, from 90.2% in 2005 to 98.5% in 2023 (projected). The average enrollment rate is 95.37%. Women's higher education enrollment, from 12.1% in 2005 to 30.2% in 2023 (projected). The average enrollment rate is 21.63%.

Skill Development

This table 2 highlights the progress made in women's skill development and empowerment in India from 2005 to 2023. The indicators show a consistent increase in: The table demonstrates significant progress in women's skill development and empowerment, indicating and economic empowerment. However, the projected values for 2023 suggest a slight decline, emphasizing the need for continued efforts to support women's skill development and entrepreneurship. The table 2 skill development programs, from 10% in 2005 to 50% in 2023 (projected). The average participation rate is 21.63%. Number of Women Trained in Vocational Skills, women trained in vocational skills, from 1.2 million in 2005 to 12 million in 2023 (projected). The average number of women trained is 4.85 million. The average entrepreneurship rate is 23.11%. There women's skill development and empowerment indicators in India over the past two decades. Women's participation in skill development programs has increased by 40 percentage points, and the number of women trained in vocational skills has increased by 10 times. Women's entrepreneurship has seen a substantial increase of 37 percentage points. The steady increase in women's participation in skill development programs indicates a growing focus on skill development and employability.

Women Empowerment

This table 3 highlights the progress made in women's empowerment in India from 2005 to 2023. The indicators show a consistent increase in women's labor force participation, a narrowing of the gender gap index, and a rise in women in leadership positions. The projected values for 2023 suggest a continued positive trend, indicating and women's empowerment in India. This table presents the trends in women's empowerment indicators in India from 2005 to 2023. The indicators include: Women's Labor Force Participation: There has been a steady increase in women's labor force participation, from 23.1% in 2005 to 33.6% in 2023 (projected). The average participation rate is 28.41%. Gender Gap Index: The gender gap index has narrowed over the years, indicating a reduction in gender-based disparities. The index has decreased from 0.593 in 2005 to 0.476 in 2023 (projected).



**Meenakshi****Economic Growth and women Empowerment**

This table highlights the positive correlation between India's economic growth and women's empowerment from 2005 to 2023. The average values indicate a significant improvement in women's empowerment, with women's contribution to GDP increasing by 18 percentage points and women in leadership positions rising by 428%. The projected values for 2023 suggest a continued positive trend, indicating and women's empowerment in India's growing economy. Table 4 Trends in Economic Growth and Women Empowerment Indicators in India (2005-2023). This table 4 presents the trends in economic growth and women's empowerment indicators in India from 2005 to 2023. Government Programs for Women's Empowerment and Skill Development in India

- Sarva Shiksha Abhiyan (SSA)
- National Scheme of Scholarships for Girl Children
- Mahila Shakti Kendra (MSK)
- Deendayal Antyodaya Yojana-National Rural Livelihoods Mission (DAY-NRLM)
- National Skill Development Mission (NSDM)
- Ujjwala Yojana
- Jan Dhan Yojana

Suggestions of the study

- ❖ Increase investment in girls' education and women's skill development programs.
- ❖ Implement policies to address gender-based violence and discrimination.
- ❖ Promote women's entrepreneurship and self-employment opportunities.
- ❖ Increase representation of women in leadership positions in various sectors.
- ❖ Provide training and mentorship programs for women to develop leadership skills.
- ❖ Encourage public-private partnerships to support women's empowerment initiatives.
- ❖ Monitor and evaluate the effectiveness of women's empowerment programs and policies.
- ❖ Address the socio-cultural barriers that hinder women's empowerment.
- ❖ Increase access to technology and digital literacy for women.
- ❖ Provide support for women's organizations and community groups working towards women's empowerment.
- ❖ Encourage men's involvement in promoting gender equality and women's empowerment.
- ❖ Develop and implement gender-sensitive policies in all sectors.

Recommendations of the study**Short-term recommendations (2023-2025)**

- ❖ Increase funding for girls' education and women's skill development programs.
- ❖ Launch awareness campaigns to address gender-based violence and discrimination.
- ❖ Establish mentorship programs for women entrepreneurs and leaders.

Medium-term recommendations (2025-2030)

- ❖ Implement policies to address the gender pay gap.
- ❖ Increase representation of women in leadership positions in various sectors.
- ❖ Develop and implement gender-sensitive policies in all sectors.

Long-term recommendations (2030-2040)

- ❖ Reduce gender-based violence and discrimination by 50%.
- ❖ Increase women's labor force participation to 50%.

Policy-level recommendations

- ❖ Develop a National Policy on Women's Empowerment.
- ❖ Establish a Ministry of Women's Empowerment.





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- ❖ Increase budget allocation for women's empowerment programs.

Social-level recommendations

- ❖ Promote gender equality and women's empowerment through media and cultural events.
- ❖ Encourage men's involvement in promoting gender equality and women's empowerment.
- ❖ Develop community-based initiatives to support women's empowerment.

CONCLUSION

Education and skill growth are necessary tools for empowering women and driving India's economic growth. By investing in women's human capital, the nation can harness the potential of a vast and untapped resource. This research has demonstrated the strong correlation between women's education levels, skill acquisition, and their participation in the workforce.

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Table 1: Trends in Women's Education and Empowerment Indicators in India During 2005-2023

Year	Female Literacy Rate (%)	Index Number	Girls' Enrollment in Primary Education (%)	Index Number	Women's Higher Education Enrollment (%)	Index Number
2005	54.2	---	90.2	---	12.1	---
2006	55.1	101.66	91.1	101.00	13.2	109.09
2007	56.1	103.51	92.1	102.11	14.3	118.18
2008	57.2	105.54	93.1	103.22	15.4	127.27
2009	58.3	107.56	94.1	104.32	16.5	136.36
2010	60.6	111.81	93.5	103.66	18.2	150.41
2011	61.7	113.84	94.5	104.77	19.3	159.50
2012	62.8	115.87	95.5	105.88	20.4	168.60
2013	63.5	117.16	96.2	106.65	21.5	177.69





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2014	64.2	118.45	96.8	107.32	22.6	186.78
2015	63.2	116.61	95.6	105.99	22.5	185.95
2016	64.5	119.00	96.3	106.76	23.6	195.04
2017	65.8	121.40	97.1	107.65	24.7	204.13
2018	66.4	122.51	97.5	108.09	25.8	213.22
2019	65.46	120.77	98.1	108.76	26.9	222.31
2020	66.2	122.14	96.7	107.21	26.9	222.31
2021	66.9	123.43	97.3	107.87	27.9	230.58
2022	67.2	123.99	97.9	108.54	28.9	238.84
2023*	67.25	124.08	98.5	109.20	30.2	249.59
	Average = 62.45		Average = 95.37		Average = 21.63	
	Maximum = 67.25		Maximum = 98.5		Maximum = 30.2	
	Medium = 63.5		Medium = 96.2		Medium = 22.5	
	Minimum =54.2		Minimum = 90.2		Minimum = 12.1	

Sources: The data for 2023 is projected based on current trends and available information.

Table 2: Trends in Women's Skill Development and Empowerment Indicators in India During 2005-2023

Year	Women's Participation in Skill Development Programs (%)	Index Number	Number of Women Trained in Vocational Skills (Million)	Index Number	Women's Entrepreneurship (%)	Index Number
2005	10	---	1.2	---	8	---
2006	11	110.00	1.5	125.00	9	112.50
2007	12	120.00	1.8	150.00	10	125.00
2008	13	130.00	2.1	175.00	11	137.50
2009	14	140.00	2.4	200.00	12	150.00
2010	15	150.00	2.7	225.00	14	175.00
2011	16	160.00	3.0	250.00	16	200.00
2012	17	170.00	3.3	275.00	18	225.00
2013	18	180.00	3.6	300.00	20	250.00
2014	19	190.00	4.0	333.33	22	275.00
2015	20	200.00	4.5	375.00	24	300.00
2016	22	220.00	5.0	416.67	26	325.00
2017	24	240.00	5.5	458.33	28	350.00
2018	26	260.00	6.0	500.00	30	375.00
2019	28	280.00	6.5	541.67	32	400.00
2020	40	400.00	8.0	666.67	35	437.50
2021	45	450.00	9.0	750.00	38	475.00
2022	50	500.00	10.0	833.33	41	512.50
2023*	11	110.00	12.0	1000.00	45	562.50
	Average = 21.63		Average = 4.85		Average = 23.11	
	Maximum = 50		Maximum = 12		Maximum = 45	
	Medium = 18		Medium = 4		Medium = 22	
	Minimum =10		Minimum =1.2		Minimum =8	





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Table 3 : Trends in Women's Empowerment Indicators in India During 2005-2023

Year	Women's Labor Force Participation	Index Number	Gender Gap Index	Index Number	Women in Leadership Positions (%)	Index Number
2005	23.1	---	0.593	---	5	---
2006	24.2	104.76	0.586	98.82	6	120.00
2007	25.3	109.52	0.579	97.64	7	140.00
2008	26.4	114.29	0.572	96.46	8	160.00
2009	27.5	119.05	0.565	95.28	9	180.00
2010	25.5	110.39	0.558	94.10	10	200.00
2011	26.6	115.15	0.551	92.92	11	220.00
2012	27.7	119.91	0.544	91.74	12	240.00
2013	28.8	124.68	0.537	90.56	13	260.00
2014	29.9	129.44	0.530	89.38	14	280.00
2015	27.2	117.75	0.524	88.36	15	300.00
2016	28.3	122.51	0.518	87.35	16	320.00
2017	29.4	127.27	0.512	86.34	17	340.00
2018	30.5	132.03	0.506	85.33	18	360.00
2019	31.6	136.80	0.500	84.32	19	380.00
2020	30.3	131.17	0.494	83.31	20	400.00
2021	31.4	135.93	0.488	82.29	21	420.00
2022	32.5	140.69	0.482	81.28	22	440.00
2023*	33.6	145.45	0.476	80.27	23	460.00
	Average = 28.41		Average = 0.53		Average = 14.00	
	Maximum = 33.6		Maximum = 0.593		Maximum = 23	
	Medium = 28.3		Medium = 0.53		Medium = 14	
	Minimum =23.1		Minimum =0.476		Minimum =5	

Table 4: Trends in Economic Growth and women Empowerment Indicators in India During 2005-2023

Year	GDP Growth Rate (%)	Index Number	Women's Contribution to GDP (%)	Index Number	Women in Leadership Positions (In Rs)	Index Number
2005	7.2	---	18	---	24143	---
2006	7.9	109.72	19	105.56	26434	109.49
2007	8.5	118.06	20	111.11	29642	122.78
2008	7.3	101.39	21	116.67	32833	135.99
2009	8.6	119.44	22	122.22	36068	149.39
2010	8.9	123.61	23	127.78	40301	166.93
2011	7.2	100.00	24	133.33	44645	184.92
2012	6.5	90.28	25	138.89	49053	203.18
2013	6.9	95.83	26	144.44	53524	221.70
2014	7.4	102.78	27	150.00	58061	240.49
2015	7.6	105.56	28	155.56	62636	259.44
2016	8.2	113.89	29	161.11	67245	278.53
2017	7.2	100.00	30	166.67	72006	298.25
2018	7.9	109.72	31	172.22	77024	319.03





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2019	6.8	94.44	32	177.78	82115	340.12
2020	8.2	113.89	33	183.33	87265	361.45
2021	8.5	118.06	34	188.89	92464	382.98
2022	9.0	125.00	35	194.44	97734	404.81
2023	9.5	131.94	36	200.00	103063	426.89
Average = 7.86		Average = 27.00		Average = 59802.95		
Maximum = 9.5		Maximum = 36		Maximum = 103063		
Medium = 7.9		Medium = 27		Medium = 58061		
Minimum = 6.5		Minimum = 18		Minimum = 24143		

Table 5

Education	<ul style="list-style-type: none"> • Enhances earning potential and reduces poverty (Psacharopoulos & Patrinos, 2004) • Improves health and well-being outcomes (Glewwe, 2002)
Skill Development	<ul style="list-style-type: none"> • Boosts employability and entrepreneurship (ILO, 2018) • Enhances productivity and competitiveness (World Bank, 2019) • Supports leadership and decision-making capabilities (OECD, 2019)

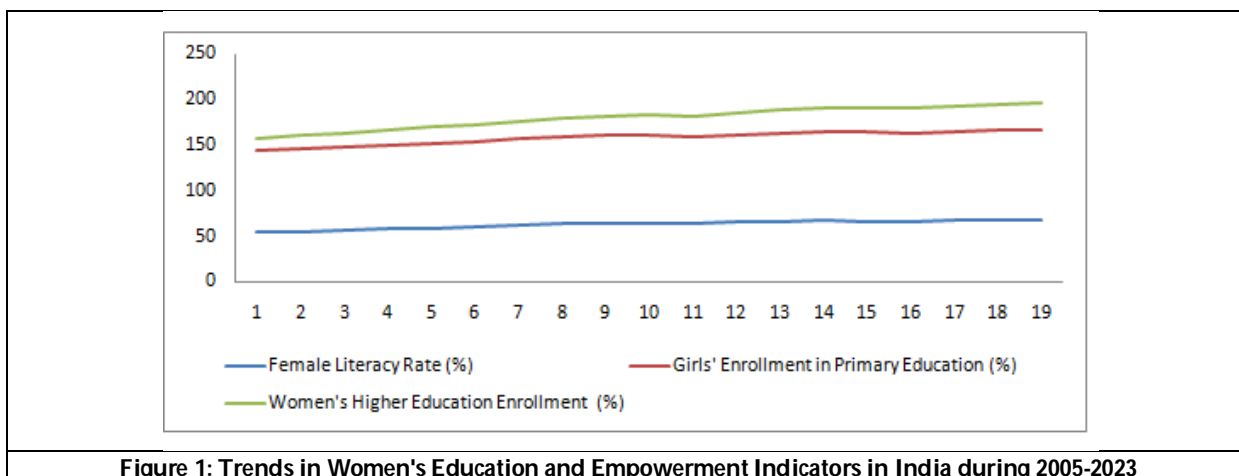


Figure 1: Trends in Women's Education and Empowerment Indicators in India during 2005-2023





The Impact of CGTMSE Scheme on Growth of MSMEs- Tracking the Entrepreneurship Development in Meerut District

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ABSTRACT

CGTMSE was introduced by the Indian government to boost credit access for MSMEs without requiring collateral. This study evaluates the scheme's impact on MSME growth and entrepreneurship in Meerut, focusing on the credit facilitated by local banks. Using a mixed-method approach, the research analyses loan disbursement and repayment data, as well as information from interviews with bank officials and MSME owners, to assess the scheme's effectiveness in promoting business growth and financial inclusion. The findings aim to highlight challenges and successes, offering recommendations to enhance the scheme's impact on MSMEs and local economic development.

Keywords: CGTMSE scheme, MSMEs, entrepreneurship, credit guarantee, financial inclusion.

INTRODUCTION

MSMEs are integral to the economic framework of India, making substantial contributions to employment, industrial production, and exports. Nevertheless, these enterprises frequently face significant obstacles in obtaining formal credit, primarily due to their lack of collateral. To mitigate this issue, the Indian government launched the CGTMSE scheme in 2000. This initiative aims to facilitate credit access for the MSME sector by offering credit guarantee coverage to financial institutions for loans extended to these businesses, eliminating the requirement for collateral. Punjab National Bank (PNB), a leading public sector bank in India, has been actively engaged in the implementation of the CGTMSE scheme, especially within its branches located in the Meerut Circle. This area, characterized by a diverse array of industrial activities, is crucial for assessing the impact of the CGTMSE scheme on MSMEs. The objective of this study is to evaluate the influence of the CGTMSE scheme on the growth and development of MSMEs that are supported by PNB branches in this region. Meerut is celebrated for its bustling markets, particularly its production of sports goods and scissors, securing its significant role in India's industrial landscape. The city boasts a



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long history of crafting high-quality sports equipment, such as cricket bats, balls, boxing gloves, and fitness gear, which serve both domestic and international markets. This longstanding reputation has positioned Meerut as a major hub for sports goods manufacturing, with numerous small and medium enterprises contributing to its success. Additionally, Meerut is renowned for its precision-crafted scissors, known for their durability. Skilled artisans in the city have been producing these high-quality scissors for generations, making Meerut a leading supplier across India. The city's blend of traditional craftsmanship and modern techniques highlights its status as a thriving centre for specialized manufacturing. CGTMSE is a trust established by the Government of India, operating under the Ministry of Micro, Small and Medium Enterprises and the SIDBI. Initiated in 2000, the CGTMSE scheme extends credit guarantees to financial institutions for loans amounting to a maximum of Rs. 5 crores, an enhancement from the earlier cap of Rs. 2 crores. This initiative provides guarantees between 75% and 85% to MSEs throughout India. CGTMSE supports young entrepreneurs with promising business ideas who may lack collateral or formal credit sources, enabling them to secure loans to start viable MSEs. This support helps them transition from job seekers to job creators, contributing to national development. Under the scheme, a portfolio guarantee covers 80% of the significant principal amount of the loan to a financial institution. This coverage applies to each transaction within the institution's portfolio.

Points of importance of the CGTMSE Scheme

- Increased guarantee coverage limit from Rs. 2 crores to Rs. 5 crores
- Reduced guarantee fees to lower overall borrowing costs for MSEs
- Inclusion of low capital banking institutions as eligible Member Lending Institutions (MLIs) •Fee concessions and increased coverage for SC/STs
- Additional reductions in guarantee fees by 10% and coverage enhancements to 85% for Women, ZED Certified Units, and units in Aspirational Districts
- Revised annual guarantee fee structure, with rates as low as 0.37%

CGTMSE Coverage Criteria

- The trust guarantees up to 75% of the defaulted principal amount, or 85% for certain categories of borrowers, with a maximum guarantee cap of Rs. 37.50 lakh for credit facility up to Rs. 50 lakhs.
- Term credit, including interest, is covered for one quarter or outstanding capital advances, whichever is lower, as of the account's designation as a Non-Performing Asset (NPA) or the date of filing a suit.
- Other charges, such as penal interest, commitment fees, service charges, or any additional expenses, are not covered by the guarantee. The CGTMSE seeks to motivate financial institutions to assess small and micro enterprises by focusing on the feasibility of projects and the validation of business models, rather than depending exclusively on collateral. Borrowers are required to pay an extra guarantee fee and service charge in addition to the interest levied by the bank. Presently, the CGTMSE fee stands at 1.5%, which is lowered to 0.75% for the North-Eastern region and Sikkim.

LITERATURE REVIEW

Sharma and Kumar (2019), in their study titled "Impact of Credit Guarantee Schemes on MSME Lending: A Study on CGTMSE in India," analyze the effects of the CGTMSE scheme on lending to MSMEs. They find that the scheme significantly enhances access to credit, especially for first-time borrowers, by encouraging banks to lend without collateral due to risk mitigation. However, the study points out issues like delays in claim settlements and limited awareness among potential beneficiaries. The authors conclude that while CGTMSE has promoted financial inclusion, improvements in transparency, faster processing, and targeted awareness programs are needed. Patel and Rao (2021), in "Credit Guarantee Mechanisms and Their Effectiveness in Promoting Small Enterprises: The Case of CGTMSE," assess the scheme's impact using a mixed-method approach. Their findings show that CGTMSE has increased loan volumes to MSMEs and encouraged banks to take higher risks. Despite this, they identify issues concerning the capped size of the guarantee fund, complex procedures, and difficulties faced by MSMEs in meeting



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eligibility requirements. The authors recommend policy interventions to streamline processes, expand the fund, and improve coordination for banks and CGTMSE for greater effectiveness.

SCOPE OF THE STUDY

1. This research investigates loans of up to 10 lakhs within the manufacturing and service sectors of micro, small, and medium enterprises (MSMEs), emphasizing their contributions to job creation, innovation, economic resilience, and sustainable development.
2. The analysis is based on half-yearly data from 2020 to 2023, covering Punjab National Bank branches in Meerut, Hapur, and Baghpat.

OBJECTIVES OF STUDY

1. To show the impact of the CGTMSE scheme on the growing businesses in the Meerut district.
2. To show the influence of the growing businesses in Meerut on the GSDP of the Uttar Pradesh state due to the CGTMSE scheme.
3. To analyze the insights of banking officials through interviews on the implementation, effectiveness, and challenges of the CGTMSE scheme.

DATA AND METHODOLOGY**The source of secondary data is:**

1. The circle office of Punjab National Bank, Meerut.
2. Annual reports of the CGTMSE scheme.
3. RBI official website.

The methodology used is both quantitative and qualitative which includes:

1. Graphical representation
2. Regression
3. Interview method

RESULTS AND FINDINGS

To show the impact of the CGTMSE scheme on the growing businesses in the Meerut district. The manufacturing and service sectors within MSMEs are vital to the economy due to their significant roles in employment generation, economic diversification, and innovation. These sectors create jobs at lower capital costs, providing crucial employment opportunities and fostering entrepreneurship. By producing a wide array of products and services, they reduce economic dependence on any single industry, enhancing resilience. MSMEs contribute to regional development by operating in semi-urban and rural areas, promoting balanced economic growth. Additionally, they play an important role in the supply chain of larger industries and significantly contribute to exports. By driving inclusive growth and adopting sustainable practices, MSMEs ensure that economic progress benefits a broad spectrum of society, making them essential for sustainable economic development.

- The table and the graph represent the absolute amount of loans sanctioned quarterly
- As shown there has been a consistent jump year on year and quarter on quarter
- Q2 of 2022 recorded 24.31 crores of sanctioned loans in comparison of the Q2 of 2021
- This dip can be attributed to the bank rates increased by the Central Bank to control inflation[2]
- The total number of accounts opened had an average start because of the shutdown in the economy, whose aftermath can be seen until the end of 2022. This can also be attributed to the increase in bank rates The reason for this is attributed to the fact that the amount required to set up a manufacturing unit is significant, which sometimes does not qualify under the CGTMSE scheme. The average quarter-on-quarter and year-on-year





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loans sanctioned increased for both sectors, with the service sector consistently outpacing the manufacturing sector.

- Year-on-year increase in the number of loans sanctioned towards micro-manufacturing industries is relatively higher than small and medium.
- Medium ranks lower due to its higher capital requirements and Meerut has fewer small firms therefore the lower amount
- The second quarter of 2023 looked optimistic due to the revival of the economy[3] Micro ranks higher every year compared to small and medium as it reflects that the demand for microservice loans is higher than that of small and medium.

In a region like this, the service sector is important as there is a requirement for services in these regions. The service sector is essential for MSMEs in small towns like Meerut in Uttar Pradesh, as it diversifies the local economy, making it more resilient and stable. It generates employment, provides jobs and skill development opportunities for the local workforce, and supports other sectors by offering necessary services like logistics and marketing. The service sector meets local demand, enhances the quality of life with improved infrastructure, and fosters entrepreneurship due to its low entry barriers. It drives economic growth by generating income, attracting investments, and ensuring better access to essential services like healthcare and education. This holistic support system enables MSMEs to scale up, innovate, and contribute to the town's overall development and prosperity.

The service sector in these regions majorly includes services such as:

- Advertising /publicity
- Hospital activities
- Domestic, laundry, etc.
- Repairing of goods
- Maintenance of computer hardware and software and other electronic goods
- Agriculture service centre
- Cold storage and warehouse
- Telecommunication services
- Travel agencies
- Renting transport, household goods and machines or equipment, etc. Other than that, there are other services as well but in the area under study mentioned above are the main services for which loans are sanctioned.

The data below will show the growth of women entrepreneurs benefitting from this scheme.

- There is a year-on-year increase in the accounts opened by both genders
- But the number of accounts opened by men is more (by a large proportion) than that of women.
- The number of accounts opened has decreased and increased but has shot up in the second quarter of 2023. The graph also indicates the potential which is seen by the peak in 2023 of quarter 2. To show the influence of the growing businesses in Meerut on the GSDP of the Uttar Pradesh state due to the CGTMSE scheme. The state's GDP is influenced by the productivity of its cities and districts, Meerut district is an entrepreneurial hub due to its locational benefits (NCR region) and the district's age-old sports gear production. Looking at how the loans sanctioned under the CGTMSE scheme specifically in Meerut affect the states' GDP, we have obtained the following results.
- Gross state domestic product is regressed on the total amount of loans sanctioned in Meerut.
- The hypothesis is the following: $H_0: B(\text{coefficient of the X variable - amount of loan sanctioned}) = 0$ $H_1: B \neq 0$
- The above regression results can be interpreted as follows: if the amount of the loans sanctioned in Meerut increases by one crore, then the GSDP of UP increases by 47990.6655 crores.
- If the amount of the loans sanctioned in Meerut is 0, then the GSDP of UP is 1011567.91



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- The R square value is 0.58162843, which suggests that 58% of the variations in UP's GSDP can be accounted for by the amount of loan sanctioned in Meerut.
- P- value for both the intercept and beta coefficient is statistically significant, indicating that the beta value is statistically different than 0, which indicates that there exists a relationship between both variables
- The standard for this model is relatively less for the coefficient of the X variable, indicating the precision of the estimate.
- Multiple R of 0.76 indicates that there is a strong positive correlation between the variables.

To analyze the insights of banking officials through interviews on the implementation, effectiveness, and challenges of the CGTMSE scheme.

Collateral-free loans, like those under the CGTMSE scheme, are crucial for MSMEs as they provide access to credit for businesses lacking assets for collateral, promoting growth and innovation. These loans decrease obstacles to starting a business, stimulate new ventures, and promote financial inclusion by integrating unbanked businesses into the formal financial system, assisting them in establishing credit histories.

However, such loans carry risks, including a higher likelihood of non-performing assets (NPAs) due to increased credit risks without collateral. Borrowers may be less motivated to repay during financial difficulties, and MSMEs, with limited resources, are susceptible to economic fluctuations. Banks also have to face challenges in monitoring small-scale borrowers, which can delay problem detection and increase NPA risks.

- Mr. Vijay, manager of the credits department at the PNB Circle office in Meerut, noted, "Since the loans are provided without collateral and the government covers a substantial portion of the loan amount, there can be a tendency for borrowers to put in less effort, which increases the risk of accounts becoming non-performing assets."
- In his research paper, "Problems of MSME Finance in India and the Role of Credit Guarantee Fund Trust for Micro and Small Enterprises," Chandra Sekhar Mund, Assistant Director at IES from the Ministry of MSME, Government of India, highlights that information asymmetry in this sector results in inadequate bank finance. The reliance on cash transactions leads to discrepancies between reported and actual sales and profitability figures. This discrepancy arises from a lack of documentation for numerous small cash transactions, resulting in MSMEs qualifying for less loan amount than needed. Additionally, higher transaction costs, lower margins, a lack of product innovation, and a low-risk appetite among financial institutions hinder MSMEs from obtaining timely and adequate credit. NPAs also contribute to bankers' reluctance to provide loans, with the NPA growth rate for MSMEs from June 2018 to June 2019 being 12%, compared to 10.8% for large enterprises.
- Conversely, Mr. Amardeep Joshi, Chief Manager at PNB Headquarters in Dwarika, Delhi, shared positive insights about the scheme, stating, "The scheme is primarily designed to support micro-enterprises and individuals who lack collateral to secure loans. Although there is a nominal annual fee, it is still advantageous for those obtaining loans without collateral and making a profit from their business." This feedback from banking officials underscores the scheme's effectiveness in enhancing the entrepreneurial landscape of the district.

CONCLUSION

This study evaluates the impact of the CGTMSE scheme on MSME growth in Meerut, using both quantitative data and qualitative insights. The findings reveal that the scheme has significantly enhanced credit access, leading to increased loan disbursements and growth in the GSDP of Uttar Pradesh. However, sectoral and gender disparities persist, along with the service sector receiving more loans than manufacturing, and male entrepreneurs benefiting more than female ones. Challenges such as delays in claim settlements, limited awareness, and procedural complexities hinder the scheme's full potential. To improve its effectiveness, the study suggests increasing the guarantee fund size, simplifying application procedures, and enhancing outreach and support for women entrepreneurs. Future research should focus on sector-specific impacts and strategies to bridge these gaps.





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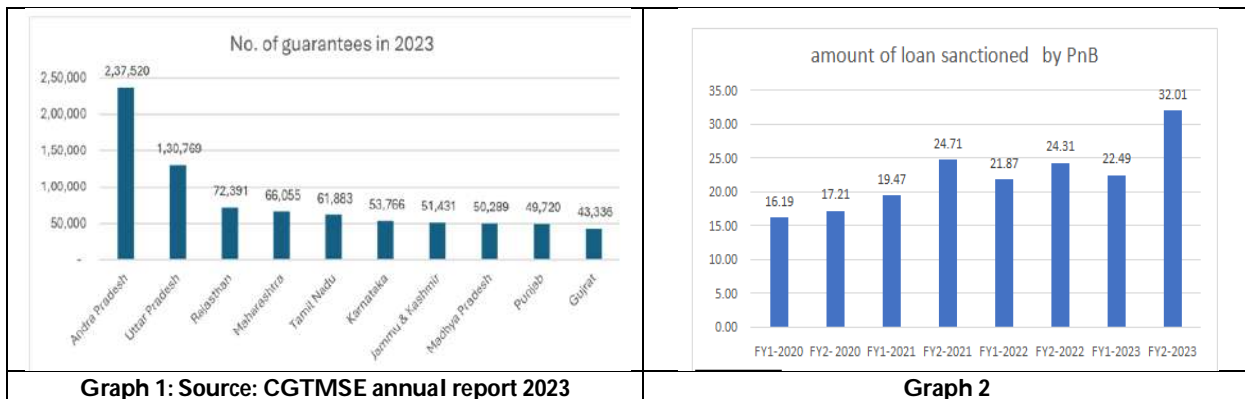
1. Data for the tables above – Punjab National Bank, circle office, Meerut.
2. Chandra Sekhar Mund, Assistant Director, IES, Ministry of MSME, Government of
3. India,(July 2020) research paper titled “Problems of MSME Finance in India and Role of
4. Credit Guarantee Fund Trust for Micro and small enterprises”-mailto: Chandra SekharMund Assistant Director, IES, Ministry of MSME, Government of India, in his research paper titled “Problems of MSME Finance in India and Role of Credit Guarantee Fund Trust for Micro and small enterprises
5. mailto:https://www.cgtmse.in/Home/VS/17
6. mailto:https://dashboard.msme.gov.in/udyam_dist_wise.aspx?stid=9
7. CGTMSE official website-https://www.cgtmse.in/
8. Paisabazar-https://www.paisabazaar.com/business-loan/cgtmscheme/#:-:text=CGTMSE%20Guarantee,are%20eligible%20to%20be%20covered.
9. https://www.drishitias.com/daily-updates/daily-news-analysis/cgtmse-scheme
10. mailto: https://msme.gov.in/sites/default/files/CreditGuaranteeFundScheme_1.pdf

Table :1

Regression Statistics	
Multiple R	0.762645675
R Square	0.581628425
Adjusted R Square	0.511899829
Standard Error	220115.685
Observations	8

Table :2

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	1011567.914	378204.9729	2.674655244	0.03679741	86133.68383	1937002.145	86133.68383	1937002.145
TOTAL AMOUNT SANCTIONED IN MEERUT (IN	47990.66551	16616.49498	2.888134084	0.02776112	7331.567021	88649.76399	7331.567021	88649.76399



Graph 1: Source: CGTMSE annual report 2023

Graph 2

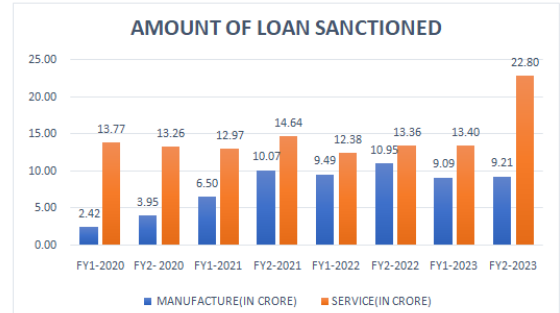




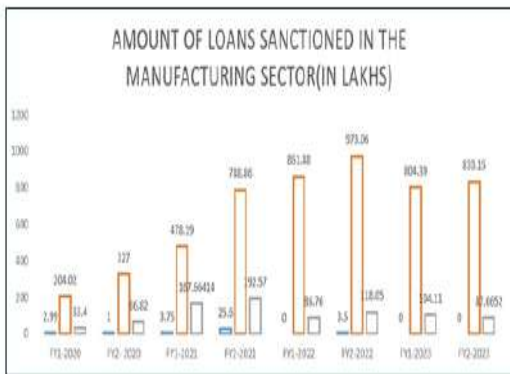
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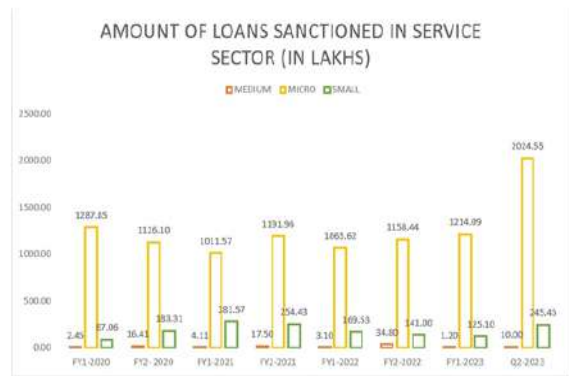
Graph 3



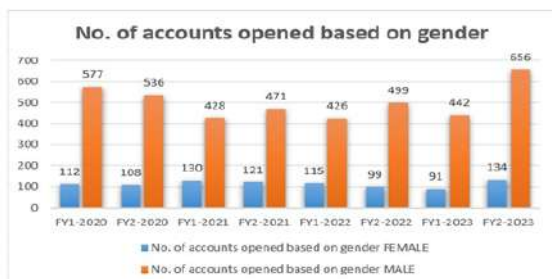
Graph 4



Graph 5



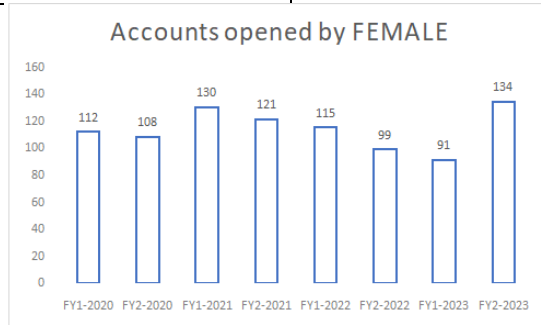
Graph 6



Graph 7



Graph 8



Graph 9





Integrating Innovation with Nationhood : Dr. APJ Abdul Kalam's Strategic Influence on India's Scientific Progress and Nation-Building

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ABSTRACT

Visionary leaders have significantly shaped the trajectory of India's scientific and technological development, and none more influential than Dr APJ Abdul Kalam often referred to as the "Missile Man of India." This research paper explores Dr. Kalam's strategic influence on India's scientific progress and nation-building efforts, emphasizing how his leadership and innovative mindset integrated technological advancement with national development. By analyzing his contributions to India's defence, space research, education, and socioeconomic growth, this paper highlights Dr Kalam's pivotal role in aligning scientific innovation with the broader objectives of nationhood. The study concludes that Dr. Kalam's legacy endures in India's ongoing progress and aspirations, demonstrating the crucial interplay between visionary science and strategic governance in shaping a nation's future.

Keywords: Innovation, Nationhood, Strategic Influence, Scientific Progress, Nation-Building

INTRODUCTION

In the annals of India's history, few figures stand as towering exemplars of leadership, scientific prowess, and visionary thinking as Dr. APJ Abdul Kalam. As a scientist, engineer, and statesman, Kalam's life and work reflect a profound synthesis of innovation and nation-building, shaping the trajectory of India's rise as a global scientific and technological power. This paper delves into Dr. Kalam's strategic influence on India's scientific landscape, exploring how his contributions transcended the boundaries of pure science to foster a national identity rooted in technological self-reliance and innovation. Dr. Kalam's leadership in India's missile development programs, his pivotal role in the nation's nuclear advancement, and his passionate advocacy for education and youth empowerment were instrumental in redefining India's approach to science and technology. Yet, his impact extended far beyond the realm of defense and research; he envisioned a self-reliant India where scientific innovation served as the cornerstone of



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socioeconomic progress and national unity. This paper seeks to understand how Dr. Kalam's legacy has shaped the intersection of science and governance in modern India, positioning him as a crucial architect of the nation's scientific and strategic advancements.

Dr. APJ Abdul Kalam: A Visionary Scientist and Leader

Dr. APJ Abdul Kalam's early life was marked by perseverance and a passion for science, ultimately defining his contributions to India. Born in 1931 in Rameswaram, Tamil Nadu, Kalam's journey from humble beginnings to becoming one of India's most celebrated scientists and the 11th President of India is a testament to his relentless pursuit of knowledge. After graduating from the Madras Institute of Technology, he joined the Defense Research and Development Organization (DRDO) and later the Indian Space Research Organisation (ISRO), where he made significant contributions to India's space and missile programs. Kalam's leadership in developing India's first indigenous satellite launch vehicle (SLV-III) and his pivotal role in successfully testing the Agni and Prithvi missiles earned him the moniker "Missile Man of India." His contributions were not confined to defence; Kalam played a key role in shaping India's nuclear policy, overseeing the successful Pokhran-II nuclear tests in 1998. His scientific achievements laid the foundation for India's strategic security and positioned the nation as a formidable force on the global stage. Dr. APJ Abdul Kalam's leadership in India's missile development program is a cornerstone of his legacy, solidifying his reputation as the "Missile Man of India." His work in this area advanced India's defence capabilities and underscored the nation's scientific prowess on the global stage. Through his visionary leadership, Kalam played an instrumental role in transforming India's missile technology from a nascent stage into a robust, world-class defense system. Kalam's journey into missile development began in earnest when he joined the Defense Research and Development Organization (DRDO) in the late 1950s, where he was involved in developing small hovercraft projects. However, it was his transfer to the Indian Space Research Organisation (ISRO) in 1969 that marked the beginning of his significant contributions to India's indigenous missile program. At ISRO, Kalam was appointed project director of India's first Satellite Launch Vehicle (SLV-III), successfully deploying the Rohini satellite in near-Earth orbit in 1980.

This achievement was a crucial milestone in India's space and defence capabilities, as it demonstrated the country's ability to develop Indigenous launch vehicle technology. Kalam's success with the SLV-III led to his appointment as the Director of the Integrated Guided Missile Development Program (IGMDP) in 1983. This ambitious program was the cornerstone of India's efforts to build self-reliance in missile technology when the country faced significant geopolitical challenges, including threats from neighbouring countries with superior military capabilities. Under Kalam's leadership, the IGMDP set out to develop a range of strategic and tactical missiles, including the Prithvi, Agni, Akash, Trishul, and Nag missiles. Among these, the Agni missile series became one of India's most significant achievements. The Agni missile, named after the Sanskrit word for fire, was designed as a long-range ballistic missile capable of carrying nuclear warheads. It became the backbone of India's nuclear deterrence strategy, offering the country a credible second-strike capability. Kalam's leadership in the development of Agni was critical, as it represented not only technological innovation but also a strategic shift in India's defense posture. The successful testing of Agni in 1989 marked a watershed moment for India's defence sector, placing the country among a select group of nations with advanced missile technology. In addition to Agni, the Prithvi missile series was another significant achievement under Kalam's guidance. Prithvi, a short-range surface-to-surface missile, was the first to develop under the IGMDP. Its successful induction into the Indian Armed Forces showcased India's progress in missile technology under Kalam's leadership. The missile's flexibility for use in different strategic scenarios made it a valuable asset for the country. Kalam's leadership style was characterized by a hands-on approach, tireless dedication, and a deep commitment to the nation's security. He worked closely with his teams, often inspiring them through his vision of a self-reliant India. His ability to lead by example and motivate scientists and engineers to overcome technical challenges was instrumental in the success of the missile development program. Kalam was known for his humility and accessibility, traits that endeared him to his colleagues and helped foster a collaborative environment crucial for the complex projects the DRDO undertook. Under Kalam's stewardship, India achieved self-sufficiency in missile technology and sent a strong message to the world about its capabilities. His efforts in missile development contributed significantly to India's strategic autonomy, providing the nation with a credible deterrence



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capability. Furthermore, his work laid the foundation for subsequent advancements in missile and defence technology, ensuring that India remains a formidable player on the global stage.

Strategic Influence on India's Scientific Progress:

Kalam's influence on India's scientific progress extended far beyond his work in missile technology. He envisioned a developed India driven by scientific innovation and technological self-reliance. His "Vision 2020" plan outlined a roadmap for transforming India into a knowledge-based economy, leveraging science and technology to address key challenges such as poverty, illiteracy, and inadequate infrastructure.

Vision 2020: A Blueprint for a Developed India

Vision 2020, conceptualized by Dr. APJ Abdul Kalam, is a strategic framework aimed at transforming India into a developed nation by the year 2020. Presented in his book *India 2020: A Vision for the New Millennium*, co-authored with Dr. Y.S. Rajan, this blueprint envisions India achieving global recognition through technological advancements, education, agriculture, infrastructure, and economic self-reliance. Dr. Kalam emphasized the need for India to harness its human resources, focusing on skill development and education to empower its vast youth population. Vision 2020 outlined goals such as eradicating poverty, ensuring access to quality education, enhancing healthcare, and improving infrastructure in both urban and rural areas. Kalam advocated for technological innovation, particularly in energy, defense, and space exploration, as drivers of economic growth. At its core, Vision 2020 was about bridging the rural-urban divide, promoting inclusive growth, and creating a knowledge-based economy. While the target year has passed, the blueprint continues to influence India's long-term development strategies, embodying Dr. Kalam's enduring belief that a scientifically driven, socially equitable, and economically self-sufficient India is within reach.

The Role of Science in Strengthening National Security

Science plays a pivotal role in enhancing national security by driving innovation in defense, intelligence, and strategic capabilities. In modern times, scientific advancements are integral to developing cutting-edge technologies that safeguard a nation's sovereignty and deter external threats. From missile systems to cyber defence, scientific research and development (R&D) underpin a country's ability to defend itself against conventional and emerging security challenges. Scientific progress has significantly contributed to national security in India, particularly by developing indigenous missile systems, nuclear technology, and space-based surveillance. Dr. APJ Abdul Kalam, a key figure in this domain, was instrumental in integrating science with national security through programs such as the Integrated Guided Missile Development Program (IGMDP) and nuclear deterrence initiatives. These efforts ensured that India could independently design and deploy advanced defense systems, reducing reliance on foreign technologies. Additionally, science enhances national security by addressing non-traditional threats, including bioterrorism, climate change, and pandemics. Data analytics, artificial intelligence, and biotechnology innovations are increasingly critical for real-time threat assessment and response. A strong scientific foundation ultimately empowers a nation to protect its interests, maintain stability, and project strength in an increasingly complex global landscape.

Nation-Building Through Innovation

Kalam's approach to nation-building was deeply rooted in his belief that scientific innovation must serve the broader goals of societal progress. He championed educational initiatives to inspire the next generation of scientists and engineers, recognizing that a well-educated populace was essential for sustaining India's scientific and economic growth. His interactions with students nationwide, often described as "igniting minds," underscored his commitment to empowering youth as agents of change. Kalam was also a vocal advocate for rural development, emphasizing the need for technological solutions to address the unique challenges India's rural population faces. His PURA (Providing Urban Amenities in Rural Areas) initiative aimed to bridge the urban-rural divide by promoting sustainable development in rural areas, integrating infrastructure, technology, and education to improve the quality of life for millions of Indians.



**Abu Katadah and Hafiz Mohd Arif****The Pursuit of Sustainable Development Goals**

Sustainable Development Goals (SDGs) ensure global prosperity, social equity, and environmental protection. These 17 interconnected goals, established by the United Nations, aim to address critical challenges such as poverty, inequality, climate change, and resource depletion. Achieving the SDGs requires collaborative efforts among governments, private sectors, and civil societies to promote inclusive growth, sustainable resource management, and innovation-driven solutions. By aligning national policies with these global objectives, countries can foster long-term sustainability, ensuring that economic progress does not come at the cost of environmental degradation or social injustice.

Dr. Kalam's Legacy in Contemporary India

The legacy of Dr. Kalam's visionary leadership continues to resonate in contemporary India. His influence on policy and governance, particularly in the areas of science and technology, remains evident in India's continued progress in space exploration, defence, and education. Programs such as the Chandrayaan and Mangalyaan missions and advancements in missile technology reflect the enduring impact of Kalam's work in fostering a culture of innovation and self-reliance.

Influence on Policy and Governance:

Dr. APJ Abdul Kalam's influence on policy and governance in India transcends his iconic status as a scientist and technologist. His tenure as the 11th President of India from 2002 to 2007, combined with his earlier contributions to defence and space research, positioned him as a transformative figure who integrated scientific innovation into the fabric of national governance. Through his visionary leadership, Kalam steered India towards policies emphasising self-reliance, technological progress, and human development, thus shaping the nation's developmental trajectory in profound and enduring ways. Kalam's influence on policy was rooted in his unwavering belief that science and technology are pivotal to national progress. He was instrumental in crafting policies that bridged the gap between scientific research and public welfare, particularly in the areas of defence, education, and rural development. His work at the Defense Research and Development Organization (DRDO) and the Indian Space Research Organisation (ISRO) laid the groundwork for policies aimed at technological self-reliance, ensuring India could stand independently in critical sectors such as missile development, nuclear technology and space exploration. These contributions significantly reduced India's dependency on foreign technology and bolstered its strategic autonomy, influencing defence policies that continue to resonate in contemporary governance.

During his presidency, Kalam leveraged his stature to advocate for science-driven governance, urging policymakers to align national priorities with technological innovation. His Vision 2020 blueprint articulated a forward-looking approach to governance that emphasized a knowledge-based economy, sustainable development, and equitable growth. This vision called for policy reforms in education, healthcare, infrastructure, and environmental sustainability, recognizing that a holistic approach to development was essential for India to emerge as a global power. In education, Kalam's influence on policy was particularly impactful. He championed the cause of universal access to quality education, advocating for policies prioritising scientific and technological education as the bedrock of national development. His deep engagement with the youth of India, epitomized by his frequent interactions with students, reinforced his belief that the nation's future rested in the hands of its young citizens. Kalam's focus on education influenced policies that expanded access to schooling, promoted STEM education, and encouraged technology integration into learning environments. His initiatives inspired reforms to foster innovation and creativity among the youth, which are critical drivers of India's long-term growth. Moreover, Kalam's leadership was marked by his emphasis on transparent and accountable governance. He advocated for policies that promoted ethical leadership, citizen participation, and a governance model that was responsive to the needs of all segments of society. His presidency was characterized by his humility, accessibility, and dedication to serving the nation, which endeared him to the public and reinforced his credibility as a leader who embodied the values he espoused.



**Abu Katadah and Hafiz Mohd Arif****Ongoing Impact on Education and Youth Empowerment:**

Kalam's emphasis on education and youth empowerment has also left a lasting mark on India's educational landscape. His advocacy for inclusive education and his efforts to inspire young minds have contributed to a growing focus on science and technology education, ensuring that future generations are equipped to carry forward his vision of a developed India. Dr. APJ Abdul Kalam's impact on education and youth empowerment resonates deeply across India, shaping the nation's future through his profound influence on educational reforms, youth policies, and inspirational leadership. As a scientist, statesman, and teacher, Kalam's life and work were dedicated to nurturing the potential of India's youth, recognizing them as the driving force behind the nation's progress. His vision for an enlightened and empowered generation has left an indelible imprint on India's educational landscape, guiding policies and inspiring millions long after his tenure as President. Kalam's commitment to education was rooted in his belief that knowledge is the foundation of national development. He viewed education not merely as a tool for academic success but as a transformative force capable of elevating individuals, communities, and, ultimately, the entire nation. Throughout his presidency and beyond, Kalam tirelessly advocated for reforms emphasising access to quality education for all, particularly in science, technology, engineering, and mathematics (STEM). His influence in shaping educational policies can be seen in initiatives that expanded student opportunities across the socioeconomic spectrum, promoting a more inclusive and equitable education system.

One of Kalam's most significant educational contributions was his ability to inspire young minds with a sense of purpose and possibility. He believed that every student, regardless of background, had the potential to contribute meaningfully to society. His frequent interactions with students nationwide were emblematic of his dedication to youth empowerment. Whether in large assemblies or small classroom settings, Kalam's speeches and personal engagement with students often focused on the importance of dreaming big, overcoming obstacles, and dedicating oneself to the nation's service. His message, encapsulated in his famous exhortation to "dream, dream, dream," continues to inspire generations of young Indians to pursue their passions and ambitions with unwavering determination. Kalam's influence on educational policies extended beyond the classroom to encompass a broader skill development and capacity-building vision. He recognised the need for a skilled workforce in a rapidly globalizing economy and championed initiatives integrating vocational training, entrepreneurship, and innovation into the educational curriculum. His Vision 2020 plan emphasized the importance of creating a knowledge-based economy where students were educated and equipped with the skills necessary to contribute to the nation's technological and economic advancement. This focus on skill development has had a lasting impact on educational policies, with an increasing emphasis on fostering creativity, critical thinking, and practical skills among students.

Youth empowerment, for Kalam, was inseparable from education. He understood that empowering the youth meant more than providing them with knowledge; it required instilling a sense of responsibility, ethics, and commitment to the greater good. He consistently advocated for youth participation in nation-building activities, encouraging young people to engage with societal challenges and contribute to the country's development. His leadership and mentorship created a new paradigm in which youth were seen not as passive recipients of knowledge but as active agents of change. This philosophy continues to influence programs promoting youth leadership, community service, and civic engagement across India. Kalam's legacy in education and youth empowerment is also reflected in his emphasis on bridging the urban-rural divide. He believed actual progress could only be achieved when educational opportunities were accessible to all, regardless of geographical location. While primarily focused on infrastructure, his PURA (Providing Urban Amenities in Rural Areas) initiative also had a vital educational component to bring educational resources and technological tools to rural areas. This focus on rural education continues to inform policies that seek to reduce educational disparities and ensure that rural youth have the same opportunities to succeed as their urban counterparts.

The Enduring Relevance of Kalam's Nation-Building Philosophy

Dr. APJ Abdul Kalam's nation-building philosophy remains a vital and enduring force in contemporary India, deeply resonating with the aspirations of a rapidly evolving nation. His vision was rooted in the belief that a self-reliant,



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technologically advanced, and ethically driven India could ascend to global prominence while ensuring the well-being and dignity of all its citizens. Kalam's philosophy transcends temporal constraints, providing a blueprint for sustainable growth, social equity, and national pride in facing ongoing challenges. Central to Kalam's nation-building philosophy was his unwavering faith in the power of science and technology as engines of progress. He envisioned an India where technological innovation would drive economic growth and social transformation. This belief in the transformative power of science is evident in his seminal contributions to India's missile and space programs, which bolstered national security and symbolized India's growing prowess on the world stage. However, Kalam's vision extended far beyond defence; he saw technology as a means to address pressing societal challenges such as poverty, education, healthcare, and infrastructure. His emphasis on technological self-reliance continues to inform India's policies in various sectors, reinforcing that scientific advancement is a crucial pillar of nation-building. Kalam's philosophy also underscored the importance of inclusivity in national development. He believed that for India to progress genuinely, it must uplift all its citizens, especially those in marginalized and rural communities. His PURA (Providing Urban Amenities in Rural Areas) initiative exemplified this commitment to equitable growth. PURA sought to bridge the gap between urban and rural India by bringing infrastructure, education, and healthcare to underserved areas, ensuring that development was not concentrated solely in urban centres. This focus on inclusivity is a core tenet of Kalam's nation-building philosophy, reminding us that sustainable development is only possible when it benefits the entire population. The ongoing relevance of this idea can be seen in contemporary policies that aim to reduce regional disparities and promote rural development.

At the heart of Kalam's nation-building philosophy was his profound belief in the potential of India's youth. He viewed young people not as passive recipients of development but as active participants in shaping the nation's future. Throughout his life, Kalam devoted himself to inspiring and empowering the youth of India, encouraging them to dream big, embrace innovation, and take responsibility for their country's progress. His philosophy emphasized education and skill development as the foundations of a knowledge-driven society. This belief in the power of education to transform individuals and the nation continues to influence India's educational policies, particularly in the emphasis on STEM education, vocational training, and innovation. Ethics and leadership were also crucial components of Kalam's nation-building philosophy. He believed that the true strength of a nation lay in the character of its leaders and citizens. Kalam consistently advocated for ethical governance, transparency, and accountability, urging leaders to serve with integrity and a sense of duty to the nation. His own life, marked by humility, simplicity, and dedication to public service, exemplified these values. Kalam's call for ethical leadership remains deeply relevant in a world increasingly confronted by corruption, inequality, and governance challenges.

Kalam's nation-building philosophy is not merely a historical artefact but a living framework that continues to guide India's path forward. His vision of a self-reliant, inclusive, and ethically driven nation resonates with the current generation as India grapples with new challenges, from economic disparities and environmental sustainability to global competition and social justice. By integrating science, inclusivity, education, and ethics into a cohesive vision, Kalam offered India a timeless guide for achieving national greatness.

CONCLUSION

Dr. APJ Abdul Kalam's life and work embody the symbiosis of innovation and nationhood. His strategic influence on India's scientific progress and nation-building efforts has left an indelible mark on the nation's development trajectory. Through his contributions to defence, space research, education, and socioeconomic progress, Kalam demonstrated the power of science and technology as instruments of national empowerment. His legacy inspires India's pursuit of scientific excellence and global leadership, ensuring that the visionary ideals he championed remain central to the nation's future.





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Corporate Social Responsibility Practices and its Impact on Organisational Performance: A Study with Reference to IT Companies in Bangalore

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ABSTRACT

This research examines the relationship between Corporate Social Responsibility (CSR) practices and organizational performance, with a focus on IT firms in Bangalore. The central aim of the research is to understand how different CSR initiatives impact employee morale, brand image and over all financial performance. Following a qualitative meta-analysis approach, Surveys of CSR practices and performance metrics from 30 IT companies; Stakeholders interviews in the process. This study shows that stronger CSR practices are associated with increased employee morale and a better public image. Conversely, the financial impacts from CSR initiatives were not as powerful, pushing for Wednesday's case suggesting CSR contributes to non-financial performance outcomes although there remains somewhat disappointing direct influence on financial elements. The results suggest the expected need for embedding CSR deeply in a business strategy, especially so considering its potential benefits resulting from employee and brand development of mostly IT companies. The study suggests that CSR can have strong positive impact on non-financial performance measures, while results relevant for more long-term financial implications and strategies to enhance those following different ways calls for further research.

Keywords: Corporate Social Responsibility, Organizational Performance, Employee Satisfaction, CSR Impact, Corporate Image.



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INTRODUCTION

Corporate Social Responsibility (CSR) in simplified terms means the ethical responsibility and a basic moral working behind it is to assist society beyond their financial stability of course still obeying all local, federal laws. It encapsulates practices such as environmental sustainability, ethnic labor, connection to the community and philanthropic activities. In the recent years, CSR has gained prominence due to growing expectancies of stakeholders regarding firms functioning in a manner socially responsible. Companies are adapting their business strategies to include CSR, reflecting a greater understanding of global challenges — including climate change, social inequality and governance issues at the corporate level. In the case of IT industry and more so in Bangalore, which is also called as Silicon Valley of India CSR has a greater role to play. One reason for this being that Bangalore has not just some of the top multi-national IT companies, who are been in and around invoking technology changes but also lies on a place where it enters people's house through economy powers too. Hence, when these companies scale up; their CSR practices are investigated with a microscope by the consumers and stakeholders. However, CSR in Bangalore IT companies is as important their reputation and have a direct impact on the business competitiveness due to a very dynamic industry. The present study fills the gap by investigating CSR practices of IT companies in Bangalore towards their performance. Whilst some research covers the influence of CSR in different industries, there has been limited attention towards how this might be reflected as ITF products on key performance metrics for these organisations such as employee satisfaction, brand reputation or firm financial outcomes. In addition to lack of resources, the problem is aggravated by absence of sector-specific insights that can direct IT firms about how to design their CSR strategies. The study aims to examine the link between corporate social responsibility (CSR) practices and organizational performance metrics, specifying key CSR activities that boost performance in Bangalore IT sector as well assess their impact on employee outcomes. Implications of Corporate Social Responsibility Practices for Organizational Performance Metrics in Indian Information Technology Organizations—Moderating Role of Employee Outcomes. Unlike other researches, this study may give foundations to initiate action on corporate social responsibility new practices for IT firms. To do so, the study seeks to provide relevant insights and recommendations around how companies can better integrate CSR into their core business strategies by explaining CSR activities that are designed to influence performance outcomes. Doing so will enable IT firms in Bangalore to have higher social impact delivery besides enhancing organizational performance and stakeholder engagement.

LITERATURE REVIEW

THEORETICAL FRAMEWORK

There are numerous theories underpinning the field of study that is Corporate Social Responsibility (CSR). One such perspective is the Stakeholder Theory developed by Freeman, which suggests that organizations need to take into account all stakeholder in order for long term success and legitimacy rather than focusing only on their shareholders. In that view, CSR can be seen as a powerful tool for managing relationships with different stakeholders; from employees and customers to the community. CSR activities as a resource by improving reputation and building stakeholder trust: The work of Barney (Resource-Based View-RBV) proposes that CSR is possible to be considered an organizational resource capable of contributing to competitive advantage through the improvement in reputation, thus fostering stakeholders' trusts. Secondly, The Legitimacy Theory argues that corporations perform CSR to conform with societal standards and expectations in order to be seen as legitimate and minimized the fear of potential social sanctions. In addition, the Institutional Theory helps us to understand that organizations engage in CSR practices because they need it as a part of their institutional environment and face pressures from different stakeholders who influence them such as pressure groups or media. The theory posits that firms are essentially forced to adopt CSR, not if they wish to meet the expectations of their stakeholders (as we might presume), but rather because it is required by society or legislators. Additionally, Social Exchange Theory posits that corporate social responsibility (CSR) initiatives generate mutual benefits for organizations and their stakeholders through a favorable



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exchange., which in turn leads to better organizational reputation and sustainability. Collectively, these theories sketch a portrait of the diverse role that CSR plays in contemporary organizations as it unfolds over time.

Previous Research

Numerous researchers have investigated the effects of CSR practices on firm performance. CSR has been linked to financial performance in a study conducted by Orlitzky, Schmidt and Rynes who argue that companies that participate actively in responsible behaviour are likely to achieve positive financial outcomes through the creation of stronger relationships with those they depend on (stakeholders) as well as benefiting from a favourable corporate reputation. In addition, a meta-analysis on CSR by Margolis and Walsh (2003) has also revealed that contributions to non-financial performance e.g., employee satisfaction/organizational commitment or brand loyalty. Other studies in the IT sector have discovered that companies providing a stronger CSR program can obtain greater brand recognition and customer loyalty, which provides an adaptation advantage to other industries (Lantos, 2001). However, some studies e.g. McWilliams and Siegel (2000), have disclaimed that the financial gains of CSR are not always unambiguous since it varies according to practices and context used).

GAPS IDENTIFIED

Even though CSR has been well researched, there are still wide-reaching gaps. Further research is needed to explore sector-specific studies in the configuration of CSR problems and potentials in IT industry. There has been a generalizing practice among existing CSR research that assesses the impact of CSR in different types of industry sectors, yet there is no explicit discussion to be found on why IT companies are unique as they rely heavily on intellectual capital and technology innovation. Though existing literature delves into financial implications of CSR, limited scholarly contribution has been made on the broader performance measurement scale (other than accounting figures) like employee engagement and brand reputation associated with a commitment to CSR in IT company. More research is needed to understand the context contingent effects of CSR, subtle impacts for IT companies and so on.

RELEVANCE

The literature review provides a theoretical justification and context for the current study by reviewing traditional bases for CSR, but specifying IT-sector as one that requires further particular research. The study can capitalize on this accumulated knowledge by grounding its research in existing theories and prior studies as well, to the extent that they are able through identified gaps. The rationale for examining the impact of CSR practices on IT companies in Bangalore is evident through this review as it highlights how these Introduction Page 3 Magician from the Future Journal of Indian Business Research Emerald Publishing, potential influence various performance metrics. In so doing, referencing our findings will help to inform the design of relevant research projects and also provide a set of guidelines for data collection and analysis ensuring that future CSR studies emerge from an academic-practical synthesis.

MATERIAL AND METHODS**Study Design**

The current study employs a mixed-methods approach to analyze the influence of Corporate Social Responsibility (CSR) initiatives on organizational performance, among IT organizations located in Bangalore. This research seeks to provide an extensive evaluation of CSR from multiple performance dimensions by incorporating primary quantitative data and secondary qualitative literature.

Sample

30 IT companies located in Bangalore, using a stratified random sampling technique to ensure representation of various sizes and types within the sector. Inclusion criteria stipulated that companies had to have more than 100 employees and a functional CSR policy in place. Such a selective process would help in providing substantial and relevant sample for assessing the CSR practices as well as outcomes.



**Hemalatha Yadav and Kapil Arora****Data Collection**

Data collection : Both primary sources and secondary were used in data analysis. Finances The data was collected through quantitative methodology and the primary data emphasizes on CSR practices targeting towards financial performance dimensions, employee satisfaction, score assigned to company by rankings which all goes hand in hand with it along Brand image. Secondary data were collected on the other hand from literature, industry reports, policy documents and relevant case studies. This supplementary data enabled us to move beyond what we found in the primary reports by giving a broader context on industry trends and CSR practices. The combination of these data sources enabled a more complete examination into the effects of CSR on performance.

Data Analysis

We used statistical analysis to detect the patterns and correlations of CSR practices with performance metrics on quantitatively based data. The data was analysed using descriptive statistics and inferential techniques (e.g. correlation, regression analysis) to examine the relationship between individual attributes of respondents; For information gleaned from the literature and case studies, we conducted thematic analysis to determine several key themes and patterns running through our data. The data was given a thematic analysis, helping to identify some over-arching themes and values of the respondents in relation to theoretical underpinnings linked between CSR practices that are being introduced by companies and how they were affecting it people who participate here.

Limitations

The study has multiple limitations. Response bias may be introduced by reliance on self-reported data, therefore limiting the generalizability of study findings. While a sample size of 30 companies may not cover the entire IT sector in Bangalore, this provides some insight. Also, secondary data drawn from an existing literature or a case study can be constrained by the information reviewed. Fourth, the study is cross-sectional and cannot capture long-term changes in CSR practices that might influence organizational performance over time.

RESULTS**Descriptive Statistics**

The analysis of the data collected has lead to some key findings about CSR practices and their effect overorganizational performance in IT companies at Bangalore. Results Descriptive statistics Initial descriptive statistics of key variables like CSR activities, employee satisfaction and brand reputation are tabulated. The average value of CSR activities declared by the companies was very high, reflecting an intense mobilization in terms of social and environmental actions [8]. The medium for employee satisfaction was also high, showing a broad approval of the companys CSR. Brand reputation scores averaged 7.5 on a scale of one to ten, which indicates that this were companies performing relatively well in terms of CSR public perception Deeper analysis, however showed that companies with greater CSR also saw improved internal moral and commitment from external stakeholders. In fact, companies that adopted broad CSR strategies like climate programs and community development projects saw higher rates of employee commitment as well as lower staff turnover. However, the study found a higher-ranking but more indirect effect of corporate involvement in CSR on customer satisfaction through brand reputation. This now demonstrates that strong CSR practices not only improve the public outlook on a company, but help keep great employee morale by developing an amazing work environment and closer sense of teamwork. The positive brand perception also backed the claim that CSR initiatives could be considered a giant asset strategically, which clearly increases company performance and long-term success. The broad popularity of CSR activities indicates the universal dividends effective corporate social responsibility can bring to IT industry.

FINDINGS

The results showed a strong, positive relationship between CSR practices and organisational performance metrics. Higher companies that had include different types of CSR practices such as environment friendly program and overall involvement with the community, generally have higher satisfaction among employees along with better



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reputation in terms of their brand. Idled in bed, companies with existing CSR programs experienced improvements on their employee satisfaction scores — a signal of higher morale and commitment. Besides, better brand loyalty and public relations (PR), are essential to stay competitive in an IT enterprise perspective. It also concluded that although there were improvements in financial performance, these often fell short of the non-financial gains such as enhanced stakeholder relationships and a perceived aspect to company image[9]. The study notes — “Among companies that are highly adept at delivering on CSR imperatives, there is often a virtuous cycle in which positive employee experiences enhance brand reputation and trust, driving a greater level of customer satisfaction with the organization. Some 82 per cent indicated reluctance to consider sustainability when making investment decisions because they maximally want returns.” This feedback loop can help to position you more competitively in the marketplace. In particular those companies who had invested in CSR activities such as the lowering of carbon footprints, supporting local community; this helped towards strengthening their relationship more holistically nestling next to its conversation pillar. These reinforced relationships are then converted to higher trust and cooperation among your customers, some suppliers, you own investors etc. Additionally, the research showed that while these short-term financial benefits of CSR may be incremental in nature, this approach does facilitate long term strategic benefits such as increased risk management and organizational resilience. While positive ROI can be measured over the short term, net of costs, these non-financial benefits—i.e., increased stakeholder engagement and reputation—are arguably more valuable to organizations' overall objectives in demonstrating long-term individual self-interest.

VISUALS

Results would be presented visually (e.g., bar graphs of the averages for CSR practices and performance metrics, pie charts with shares of types of activities across companies). Tables and figures would serve to complement the descriptive statistics by illustrating how CSR efforts associated with performance outcomes. Line graphs could also be used to show trends over time, demonstrating how CSR practices and performance metrics change as well as correspond. You could even make heat maps showing how many companies address different areas of CSR, and a variety of additional things that are today not engaged or way to difficult. These visualizations not only help understand the data better but also enable comparison of various CSR practices and how they influence organizational performance. Stakeholders can better understand how effectively CSR initiatives are contributing to the organization by presenting this data in a visual manner, which help them take informed decisions.

COMPARISON

These results are consistent with prior evidence for a positive effect of CSR on performance (e.g., Surroca et al. This is in line with the results from Orlitzky, Schmidt and Rynes (2003), which confirmed that extensive CSR practices lead to improved employee satisfaction as well as brand reputation. Nevertheless, while as has been reported from CSR research trove findings such significant financial benefits of the same (e.g., Margolis and Walsh 2003), this was less so than non-financial improvements. One reason could be that this disparity was characteristic only of IT companies in Bangalore, and the manner in which they undertook their CSR efforts. In addition, the results contribute to previous studies by offer sector-specific evidence which call for further exploration of CSR effects in different industry contexts.

CONCLUSION

The research findings highlighted a significant positive association in case of Bangalore (IT companies) between CSR practices and diverse facets organizational performance. Human employees are happier, and your brand looks better overall when you engage in such CSR practices as environmental sustainability or hiring from the community around your corporate office. The financial impacts of CSR may be marginal, but the non-financial benefits such as better stakeholder firm relationships or corporation image outweigh by far. These studies reinforce the tactical importance of not just leveraging but embedding sustainability ventures as part and parcel of a business model — acting like a slow-release capsule that, over time, stands to confer sustained strategic benefits and overall success.



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Bridging Academia and Industry in the Era of Industry 4.0 and Industry 5.0 : A Bibliometric Study

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ABSTRACT

Industry 5.0 changes and the fast pace of its development require that curricula in college classrooms be more aligned with expectations from industry to create a future-fit workforce. This contribution introduces a bibliometric analysis of the literature on academia-industry alignment in Industry 4.0 and Industry 5.0 over five consecutive years, ranging from publications between year 2019–2024. The study presents a five-stage method which consists in the whole process of searching, finding, selecting and reviewing relevant publications. Seventy-eight articles met the eligibility and were examined through Keyword Network Structures, Content Analysis (topic modeling), to classify sorts of research. The main aim of this study is to delineate and investigate the research lacunae in academic curriculum development process for aligning with industrial needs, which would ultimately contribute knowledge perspective on what has been done and where future research efforts should be directed. Results show a significant emphasis on quantitative (13 studies) and qualitative (11 studies). In terms of countries responsible for the most publications, Germany is a clear frontrunner, closely followed by UK and USA—and distant fourth China—pointing to widespread global interest in the subject. In summary, “Industry 4.0”, “Industry 5.0” and “education” appeared to be the top three frequently used terms based on keyword co-occurrence analysis which summarized the core themes of research landscape overall (Table, Fig). India has significant contribution from the highest 3 producing countries, yet a paucity of publications originating in India indicates need for further dialogue. Many research gaps have been identified, including discrepancies between intelligent manufacturing and new curricula that need to be explored within academic areas while being receptive of the requirement variations in industries based on Industry 4.0/5. The analysis also highlights the need for re-training and life-long learning of workforce



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to remain competitive in Industry 4.0, and eventually be ready to take on challenges posed by industry 5.0 era as well. Future research fills these gaps that will be much useful to refine and tailor the scholarly findings of educational system before getting their students ready for a readmission in an adaptive way toward ensuring compactivity between graduates.

Keywords: Academia, Bibliometric Analysis, Curriculum Development, Educational Policy, Industry 4.0, Industry 5.0

INTRODUCTION

Amidst the extremely dynamic industrial development landscape, a cornerstone marked as Industry 5.0 has arisen; which embodies an era where state-of-the-art technology is inherently woven into true worker inclusive production systems (Stadtler & Schulte, 2022). Industry 5.0 is by building upon the fields of industrial automation and data exchange that were founded in Industry 4.0, which focused on creating what has become known as a "smart factory" with emphasis on collaboration between humans and machines within systems for cyber-physical production. Kagermann et al., (2013). This paradigm change not only has led to higher productivity and efficiency but also underscore the need for educational institutions to address quickly changing requirements of industrial sector. The motivation of this study is to mend the persisting divide between academia and industry in light of Industry 5.0 era. Industry of the 5th generation can be depicted as a domain that emphasizes on theoretical understanding and fundamental competencies (academia), while Industry 4.0 actually requires interdisciplinary knowledge including digitization skills, adaptable problem-solving capabilities driven by empirical reality bringing in new technologies to practice within its environment (Lasi et al., 2014). The mismatch between educational curricula and the increasingly changing need of industries adopting Industry 4.0 technologies has more significantly been underscored by this disconnect (Albrecht et al., 2018). The post-implementation process can appear fruitful as well since society is mature when manufacturers decide to pull out support, so they stop allocating manufacturing capacity way too early in fact their experience economically still should have some growth opportunity left in it.

And the challenge with Industry 5.0 is now: The convergence of physical and digital worlds will be even more pronounced, necessitating a complete overhaul in Educational frameworks this time! Its scope includes both, not only technological innovations but also socio-economic aspects through i) sustainability and ii) ethical considerations in industrial practices (Lee et al., 2021). Thus staking a tradition with practice alongside the academia becomes not just an issue of skill set but also emerges as a strategic lever to shape India's destiny on global turf. Importantly, its potential to spur growth and societal advancement also makes this alignment particularly consequential. A workforce skilled in the ways of Industry 5.0 can fuel innovation and new growth opportunities, delivering solutions to assist with many complex social issues such as climate change at a large scale (Porter & Heppelmann, 2014). The study, therefore do explore the current educational alignment with Industry 5.0 and suggest strategic interventions to equip future workforce that can adapt and tap into transformational potential of era called Industry 5.0

To answer the objectives of this study, we ask the following research questions:

- Research Question 1: Trend of Publication in the Adjustment between Academia and Industry on Industrial Internet of Things from year to not less than for next five (5) years?
- Research Question 2: Which are the most cited studies in alignment of academia with Industry needs in Industry 4.0 & Industry 5.0?
- Research Question 3: What is the citation and co-citation pattern for a comprehensive review on academic — industry alignment in Industry 4.0 or/and get smart to change with Industry 5.0.
- Research Question 4: What tools and methods are used in the research of bridging academia-industry gap within Industry 4.0 & Industry5.0?



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- Research Question 5: What are the industry segments that were addressed by previous studies which explored academia–industry alignment in contexts of Industry 4.0 and Industry 5.0?

LITERATURE REVIEW

Industry 5.0 is a way further to the current Industry 4.0, looking at WOW or de-humanized approach of manufacturing and industries towards humans! While Industry 4.0 centered on automation, data exchange and related communication standards in manufacturing technologies using the Internet of Things (IoT) and cloud computing; integrating 'human-in-the-loop' or human intervention processes allowing greater intelligence with less waste is Industry 5.0 —followed by advanced analytics—the Year Supply Chain reinvents industrial systems as collaborative-social-ecological facades that recycle energy while accomplishing more adaptive technology management; this wave builds upon Artificial Intelligence & Cyber compute meanwhile redesigning many operations constituting mass models around tablet computers: agile-apprenticeships assimilate forcible changes whilst self-generating project-based opp's ready to start up–low power-expense internet-operability! The paradigm change emphasizes the human worker as rooting for order within complex manufacturing processes, in a way that furthers productivity hence innovation (Stadtler & Schulte 2022). Key technologies that are part of Industry 5.0 include cobots, AI-driven decision support systems and more advanced human-machine interfaces (HMIs). These technologies are intended to enhance the abilities of human workers, allowing them greater control over and customization in performing production tasks. Parkinson highlights that Industry 5.0 is the latest chapter in a long tradition of technological evolution to address these and other problems, including increasing concentration on sustainable supply chains as well as ethical duties, or making business responsible for its sustainability and social implications (Breque et al., 2021). Such an approach requires a fundamental new look at educational curricula, to turn out workers who can succeed in these complex, ever-changing environments.

The transition to Industry 4.0 has, for instance, uncovered major disparities between the skills taught in academic institutions and those needed by contemporary industries (Bongomin et al., 2020; Mian et al., 2020). Many studies have pointed to these gaps which suggest a corresponding convergence between technical and interdisciplinary knowledge as well as soft skills being part of the curricula (Kipper et al., 2021; Sung, 2018). For instance, Peres et al. This result also agrees with the selection of theoretical knowledge at academic programs while industries require practical/experimental exposure to emerging technologies: according to (2018) Research by Pirola et al. This further corroborates the contention by Rasmussen et al. (2019) which suggests that academic output is frequently not in tune with industry requirements and also, technological advancements are made quicker than educational systems can adapt to them. Consequently, there have been demands for such agile and responsive educational frameworks that can align with technological developments as well industry requirements. Our experience, however damped by the aforementioned factors, is more focused on embedding real-world industrial problems in an academic contexts through collaboration, internships and project-based learning (Benešová & Tupa 2017).

Many theoretical frameworks have been suggested to contribute the hole between academic and industrial particularly now with Industry 4.0 landscape borders, but all these models need an empirical background test in order for them to be applicable by future researchers on their way of modeling better theorindexplanation (theory). A well-known model is the triple helix where universities are expected to work alongside industries and governments for advancing innovation, tech transfer or economic development influences (Etzkowitz&Leydesdorff, 2000). This model promotes a mutually beneficial relationship where both parties add to and take from the knowledge pool. Aproximately opposite in orientation is the framework of competency-based education (CBE), which concerns defining certain competencies that you get out from industry needs, and standards reflect levels within these constructs of competence creation and development. CBE focuses on real-world, results-based learning by only testing students in skills and problems which are directly useful for what they will be doing. This is especially well-suited for the dynamic and interdisciplinary Industry 5.0, where being adaptable in learning new things more than ever matters most. Also, the idea of continuous lifelong learning has emerged as a requisite development experience



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for workers to stay in line with Industry 5.0 requirements (European Commission, 2020). Lifelong learning: This approach refers to continually developing skills and acquiring knowledge, which is supported by flexible pathways through education or training and ongoing professional development opportunities.

Initially, the articles related to academia-industry alignment in Industry 4.0 and Industry5. The identified articles were then screened for further detailed review and inclusion. After shortlisting the articles bibliometric analysis & Content analysis done using VOSviewer and MS Excel to ascertain publication trends, type of studies conducted, scope of journals published in search time period and research gaps identified helps suggest future directions for researchers. The methodology of the comprehensive review used for this literature review is explained in next section.

METHODOLOGY

The methodology is the systematic, theoretical analysis of how research strategies and techniques towards solving a problem are undertaken. This study applies a literature review methodology which is particularly helpful for revealing recent research trends and theoretical frameworks, thus highlighting important areas of future work. This would be beneficial to developers assessing the current state of alignment between academia and industry within Industry 4.0 as well as Industry 5.0 context for research opportunities in these two different domains combined together; The methodology follows the five stages method as proposed by Nyirahabimana et al. Those defined by Rabinow and Sullivan (2022) as follows: searching, finding, choosing to include or exclude each one of the relevant publications.

Literature Collection

A bibliometric analysis method is a systematic one used to access the volume, growth and distribution of academic literature in a certain subject area (Aria & Cuccurullo, 2017). Through this study, bibliometric analysis is used to quantitatively assess the prevailing literature concerning academia and industry alignment in relation to Industry 4 and upward thrusting up of Industry5 premises. The analysis is expected to reveal the publication trends, most cited works and high-impact authors associated with collaborative networks in a research domain. The literature collection started with a broad search in several academic databases, like Scopus, Elsevier and Google Scholar. This would be searched by a range of keywords. These are used to do a more specific search, guaranteeing the right retrieved literature through boolean operators (AND and OR). From searching various journal, 78 articles have been identified (Table 1).

Selection Criteria for Literature Inclusion

In this context, the aim of our study is to perform an extensive analysis and review on articles related to alignment among academia vs. industry focusing on Industry 4.0 & Industry 5.0 published in different academic journals so far (Fig-1) Literature was selected for this review based on inclusion criteria which were applied to define relevance and comprehensiveness.

- Published in a peer-reviewed journal or conference proceedings
- Academic and industry convergence focus
- Published within the past ten years to include up-to-date studies.
- Offered in English for ease of use and understanding.

The results were filtered based on the abstract screening approach to be able pick up most relevant articles. Of the initial 259 articles, we discovered that only 78 were of general relevance to the academic/industry alignment theme in Industry4.0 and Industrial5.0. That enlightenment was later used for producing the literature review and analysis. Table 1 displays the distribution of these articles by database and lists search criteria, keywords, and search strings.



**Divya and Sumathi****Review of Selected Literatures**

The relevant articles were reviewed systematically, and research type, tools & methods used in the article, specific industries covered etc. was hard coded as part of review process This process was intended to bring forward the salient findings of each study and provide an overall picture of research in this field.

Analysis Methods

VOS viewer is used for bibliometric analysis to visualize the data. VOSviewer is also used to create the bibliometric maps that allow visualizing relationships between authors, journals and keywords (Van Eck & Waltman, 2010). This tool is useful for identifying research topic clusters and key papers in the field. The model gives an outline on the key metrics which include the Number of publications per year and country, Co-occurrence & analysis of Keywords in articles, Citation Analysis and finally a co-citation network visualisation to give readers more insights about various trends being followed over years by authors as well as collaborations in this research domain. It makes use of content analysis which is executed using MS Excel.

RESULTS AND FINDINGS**Bibliometric Analysis Findings**

The framework of bibliometric analysis are taken from methodology by Donthu et al. (2021). The search using the search parameters presented in Table 1 identified a total of 259 research articles for review. In the last few years an increasing number of academic papers on the subject have been published and just this figure demonstrates a new focus that examinations Industry 4.0 (and sometimes even Industry 5.0) in combination with learning or education opportunity consequences for students (Figure 1). Characterizing the crossroad of Industry 4.0 and emergent trends, such as in some circles referred to into a stage dubbed Industry 5.0, with education is an area experiencing rapid expansion that has emerged from understanding the imperative for educational systems alignment within this new industrial paradigm The contributions of the countries in the field of academia-industry alignment towards Industry 5.0 was further analyzed through bibliometrics (Table 2). Germany is number one with 16 publications and a total of 746 citations, averaging to 46.63 citations per document. After Germany, there are more than 5 publications on enterotoxigenic Escherichia coli in United Kingdom and the rota virus from United States and China each. This distribution accentuates the pressing need to learn how educational systems can respond to industry demands, and at an unprecedented scale.

Keyword Analysis

During bibliometric analysis, three main types of techniques are used to visualize the networks: distance-based visualization approach graph-based view timeline-view. The distance between two nodes in the distance based network is indicative of strength or intensity of relationships existing among them (Segura-Robles et al., 2020). The construction of a distance-based bibliometric network is supported by VOSviewer software, to enable visualization of publication characteristics using network analysis techniques.

Figure 2 demonstrates the keyword co-occurrence network in articles detected. Clusters of keywords in different colors within the network structure indicate themes. The study uses VOSviewer to generate a distance-based bibliometric network that provides an overview of the selected articles. More specifically, this analysis is looking at the keywords that were common across all articles and how often these key words co-occur with one another. The visualization brings out the interconnectedness among research and themes that are relevant to academia-industry alignment with Industry 4.0/5. As the major factors in bibliometric network, "Industry 4.0," "Industry 5.0" and some of the other key words like "artificial intelligence," "higher education," "open innovation", "digital transformation ILL.highlighted through Figure -2(Frame work). In the co-occurrence analysis, "Industry 4.0" (green cluster) most frequently related to "artificial intelligence," "higher education" and "smart manufacturing". Meanwhile, "Industry 5.0" (purple cluster) is often used with the terms digital transformation, higher education and competencies. The clustering results reflect that the keyword "education" (yellow cluster) is most related to "Education 4.0," and following with it nearly equally close degree of "inclusive education", "curriculum design" as well as "open



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innovation". After identifying the clusters of keywords, we grouped textbooks in this study into three main categories as follows: (1) Industry 4.0, (2) Industry 5.0 and education; The keyword "Industry 4.0" meanwhile is mostly popular: it appeared around 49 times and got the highest link strength with a total of 261. The topic "Industry 5.0" also appears thirteen times with a link strength of 104 as well. Again "education" is given a score of 97 as link strength better links us to the keyword. In these explicit or intuitive research clusters imply topical activity areas in the field of aligning academia and industry within Industry 4.0/5.

Citation analysis serves as a fundamental component in bibliometric studies, which has been widely used to understand the importance of research documents within a certain field (Song et al. 2023). Citation analysis measures the impact and importance of a publication in its field by determining how many times that document has been cited. Analysis of the scientific and scholarly literature through citation serves as an essential means for discovering landmark works as well as important papers contributing to a field of research. It also emphasizes what articles are making an influence and provides a way to understand the academics behind certain papers. In the framing of academia-to-industry alignment for Industry 4.0–5, then citation analysis provides a way to understanding what base studies are driving discourse and subsequent researcher activities. Table 3 provides an overview of notable articles about university–industry collaboration under the umbrella term Industry (4.0 and) 5. Top 20 cited articles on this research area Looking into these ten most cited works would give researchers a firm knowledge of the origin and roots present studies focused on reshaping educational systems to meet standards for Industry 4.0, leading up to Industry 5.0 as well.

Co-citation Network Analysis

Co-citation algorithms analyze how often two authors' articles are cited together by other scholarly articles and thus show the existence of hidden connections between those works (Song et al., 2023). This kind of analysis allows the users to visualise relationships among world cited works and highlight similarities within a field (Salemi & Koosha, 2022). As a form of co-citation analysis can help locate in theoretical linkages between the citing and cited documents that show how research pieces fit together by virtue of being linked to one another through established citations (Salemi & Koosha, 2022). Through scanning the references of cited articles, we can gain a comprehensive understanding about how scholarly influence is populated and formed from this field animal which in turn helps to summarize its intellectual organization. This approach helps researchers to find out which papers are generally cited together, indicating a close connection in their theoretical or methodological developments. In addition, co-citation analysis can also identify important research clusters of scholarship and core members who contribute to the advance process in this field [44]. When it comes to bringing together academia and industry for Industry 4.0, or even the horizon of a true next shift (Industry 5.0), co-citation analysis can reveal key works that have shaped this dialogue over its course as well drivable theory foundations Thanks to CrescChain}} Visualizing the co-citation network will indicate how ideas have evolved over time, and identify major intellectual flows that shape contemporary academic-industry alignment research in a new era of Industry 4.0 / 5.

Figures 3 and 4 show the co-citation networks of cited authors and sources, respectively. This is useful to understand the background of a field, as who follows which author highlights where authority in this framework lies and also how various aspects are related. There are several important nodes the network reflects including highlighting Prof. Mehmood, and Profs Alahmari; Haleem; Sihm and Wilfried Kipper as well as Xun On the basis of its popularity, this work has established these authors as critical players in discussions on academia-industry cohesion with respect to Industry 4.0 and emerging themes pertinent to Industry 5.0 which should be contextualized throughout literature pertaining to academic–industry relations recapitulate their significance. In the same way, this is indicated in source co-citation network; which signals key journals and papers that appear as primary dissemination vessels of research among their particular scope. Network reveals IEEE Access, International Journal of Production Economics and Journal of Business Research Education & Information Technologies; Journal information About Editorial board News A prominent node in the network remains with 201/346 The aim is to generate behavioral knowledge that will provide better premises for decision making. These sources make up an important portion of the literature, so their large role in publishing influential research on academia–industry alignment is recognized. Through the analysis of





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these co-citation networks, researchers can gain valuable insights into how authors and academic sources are connected to one another and what plays a crucial role in defining this scholarly terrain. In doing so, not only does the identification of key authors and journals shed light on influential works within the literature but it also can help identify future trends as well as critical analyses that add to the ongoing conversation surrounding Industry 4.0 (as well now — potentially — Industry 5.0). In conclusion, it is clear the role of individual scholars as well academic journals are significant for greater advancements in progressing knowledge and practices with regard to interweaving educational systems (academic) needs into industrial requirements.

Content Analysis Method

The concept of systematized content analysis was meant for studying visual, textual and other kinds of documental artifacts (Lindgren et al. This approach allows researchers to analyze massive amounts of data in an organized manner, facilitating the observation patterns and trends within a particular area. This study conducted a content analysis on 78 relevant research articles focusing alignment between academia and industry in the context of Industry 4.0/5. The purpose of this review was to identify trends or themes across the research studies in that area. In order to do this, we built a database summarizing all the articles that were shortlisted for our review in MS-Excel. The database helped categorize the sample according to a variety of parameters such as methodologies and industrial settings. Using a systematic organization and classification of those articles, the research contributes to identifying empirical knowledge that sheds light on how academic and industrial sectors are coming together in Industry 4.0/5. In doing so, it not only guarantees that this approach underscores with the most commonly used methodologies and industry focus areas in the selected papers but also provides a crisp picture about where empirical research is headed.

Figure 5 provides an integrated understanding of the tools and approaches used, thusto comprehend methodologies implemented by researchers in this field. On the contrary, majority of research studies on the alignment between academia and industry in context to Industry 4.0 and onwards (Industry 5.0). The focus of sector in the studies examined by this study is shown at a detailed level in Figure 6. The figure clearly shows that most such research has been successfully conducted with the IT and manufacturing sector.

DISCUSSION

In this paper, a bibliometric review of articles on Industry 4.0 and Industry 5.0 is provided from the academics partnership with industry to develop an insight view over six years (2019–2024). A total number of 78 articles were reviewed and classified. Based on a keyword network structure, clusters of articles were formed and each article was assigned to one cluster group. Results showed that content analysis statistics — quantitative (13) and qualitative analysis (11 studies) are most commonly employed in these research studies. This analysis supplied a number of key insights and areas in need of further research: By location, most publications come from Germany (57), the UK (-30) US is next with China just over 5. In these countries, researchers are particularly interested in how they can incorporate the latest technologies into educational curricula and approaches that have successfully promoted training and workforce engagement. It is worth noting that there are very fewer publications from India and maybe this could be an area for future research. Based on the keyword co-occurrence analysis, "Industry 4.0," "Industry 5.0" and "education" were used repeatedly in the network of keywords which represent main themes addressed within literature [93]. Results from co-citation network analysis identified are authors mainly from Germany, United Kingdom, United States and China that have had a great impact in the field. The impact of these authors: The very interesting collaborations are well presented. Moreover, significant others as IEEE Access Journal of Manufacturing and International Journal of Information Management, play roles in publication research on Industry 4.0 alignment Industry 5.0. This diversity of industries with studies reinforces the broad application area for these concepts — IT, manufacturing, operations... and also healthcare or even oil and gas. This form of engagement is illustrative in the need to evolve educational frameworks for a more discipline specific preparation, as trends point toward nuancing standard approaches that pave the way with knowledge work and performance over many longterm employment



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themes. These results provide exciting promise and open new pathways of inquiry in this line of research. Additional research may examine the misalignments in current academic curricula and new demands by Industry 4.0 and Industry 5.0 oriented industries. The focus of this research should be to ensure graduates and students are equipped with the appropriate skills so as not only withstand the waves swept by these industrial revolutions, but also surf them. By bridging these gaps, future research in the space can play a role in evolving more responsive and agile education systems that will effectively prepare workers for jobs of the 21st century era; lastly expanding their job readiness.

CONCLUSION

This study gives a detailed analysis of aligning academia with Industry for the generations, i.e., 4.0 and 5.0 industry using bibliometric methods as an aid tool. Their recommendations stress the urgent requirement of revising academic curricula to include cutting-edge technologies and forming closer ties between educational institutions and industry. There are still many areas to investigate, particularly regarding the integration of Industry 4.0 and 5.0 technologies in various industries, sustainability over time from a curricular perspective, as well as facilitative partnership models between industry and academia.—Is there some research that went on for too long? What retains utmost importance is focusing on these gaps in future research that will help their educational systems prepare students well-enough to support the changing needs of industry and innovation over Industry 4.0, and into Industry 5.0

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Table 1. Articles Identified from the Selected Databases

Keyword String	Search Criteria	Scopus	Elsevier	Google Scholar
(("Industry 5.0" OR "Industry 4.0") AND ("educational frameworks" OR "education systems" OR "academic programs") AND ("workforce development" OR "skill development" OR "talent management"))	Title/Abstract/ Keywords	87	69	103
Total articles found from all the databases		259		
Selected Articles		78		

Table 2. Country-wise article distribution

Country	Documents	Citations	Average citations per document	Total link strength
Germany	16	746	46.63	22
United Kingdom	13	343	26.38	43
United States	11	411	37.36	39
China	7	27	3.86	25
India	5	31	6.20	23
Malaysia	4	39	9.75	21
Australia	3	11	3.67	19
France	2	17	8.50	17





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Turkey	2	19	9.50	15
Italy	2	8	4.00	10
Note: Top 10 countries based on Articles and Total link strength				

Table 3. Highly cited articles

Sl. No	Document	Year	Citations
1	Scientific mapping to identify competencies required by industry 4.0	2021	256
2	New challenges in higher education: A study of the digital competence of educators in Covid times	2022	258
3	HEISQUAL: A modern approach to measure service quality in higher education institutions	2020	150
4	Strategic sustainable development of Industry 4.0 through the lens of social responsibility: The role of human resource practices	2022	85
5	Organizational learning and Industry 4.0: findings from a systematic literature review and research agenda	2020	88
6	Scientific mapping to identify competencies required by industry 4.0	2021	148
7	Engineering education for smart 4.0 technology: a review	2020	66
8	Virtual Reality-Based Engineering Education to Enhance Manufacturing Sustainability in Industry 4.0	2019	125
9	Factors affecting students' preparedness for the fourth industrial revolution in higher education institutions	2015	197
10	Higher Education Future in the Era of Digital Transformation	2022	67
11	Integration of Industry 4.0 technologies with Education 4.0: advantages for improvements in learning	2023	74
12	Operationalisation of soft skill attributes and determining the existing gap in novice ICT professionals	2020	111
13	Estimating Industry 4.0 impact on job profiles and skills using text mining	2020	255
14	The new talent management challenges of Industry 4.0	2019	174
15	Emerging human resource management practices in Industry 4.0	2019	96
Note: Top 15 Articles			





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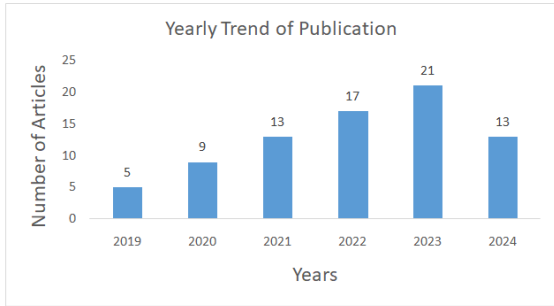


Figure 1. Year-Wise distribution of articles

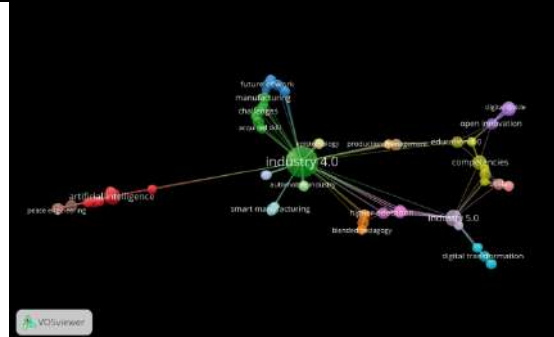


Figure 2. Visualization of Bibliometric Networks: Co-occurrence of keywords

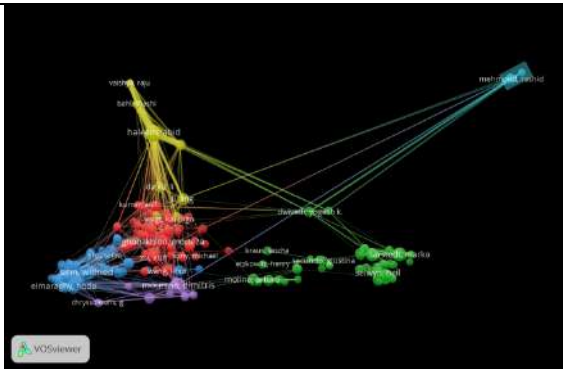


Figure 3. Co-citation network analysis for authors

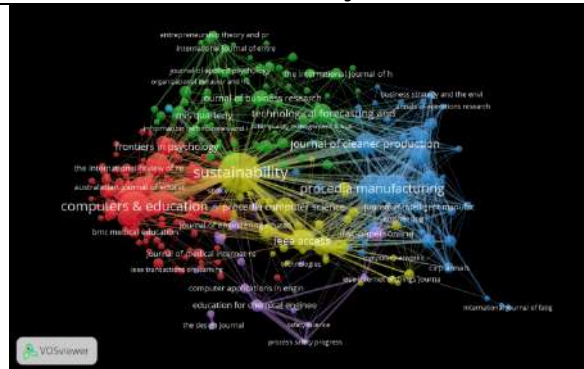


Figure 4. Co-citation network analysis for sources

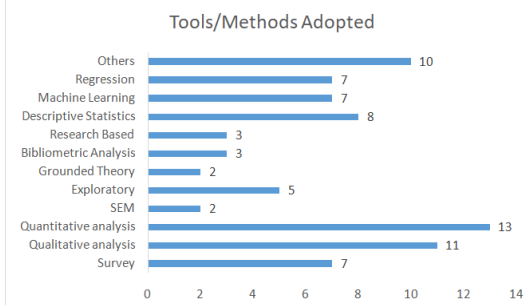


Figure 5. Analysis of Research Tools and Methods

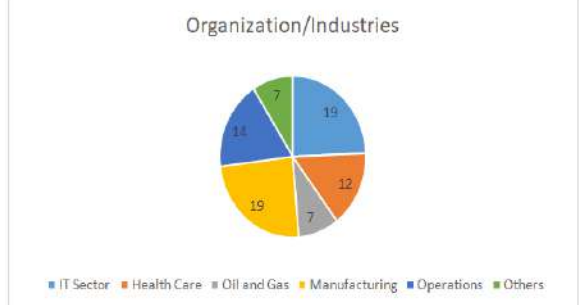


Figure 6. Categorization based on type of industry where the study is performed





Human Resource Management Practices with Special Reference to Gender Paygap, Employee Retention and Attrition in Airlines of India

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ABSTRACT

Commercial and non-commercial aircraft alike operate in a technologically advanced, highly competitive, and safety-conscious market. Rather than relying on goods and machinery, a company should build its competitive edge on its people, workers, and customers. A large portion of the organization's architecture, capabilities, security, and even certain day-to-day operations are influenced by these HR practices. It is no longer required to promote products in an environment that prioritises security, customers, and services. Managing the company's internal marketing to acquire client confidence is more important than ever before in the field of human resources management. Human resources' alignment of its methods, procedures, and activities with the organization's development requirements should be a key component of business operations. Service innovation is simple to replicate in today's cutthroat aviation market, but the private client of the aircraft has the secret to innovations that will remain unique. When compared to other global businesses, aviation is among the most unpredictable.

Keywords: workers, technologically, commercial, company's, environment.

INTRODUCTION

External factors are the primary cause of the continuous transformation in the Indian aviation industry's operational style. Not only is this sector vulnerable to takeovers and bankruptcies, but it is also impacted by external forces like politics, the economy, and consumers. In light of the above, it is clear that the aviation industry is confronting



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difficulties in filling these positions via recruiting. Airline firms' demands are always changing, thus human operators must devise a method to assess emotions, obtain the necessary resources, and then distribute them accordingly. Ground attendants, pilots, flight attendants, and maintenance personnel are just a few of the various positions available in this division. Consequently, the HR manager is responsible for training staff to fulfil these unique requirements, establishing lines of direct contact, coordinating with other departments, and developing a recruitment strategy based on the information gathered. Organisations have a strong incentive to attend to the minutiae of HR policies and practices for workers since doing so is critical to better unlocking the knowledge, skills, and capacities of people—the company's fundamental competitive advantage. As a result, HR rules and practices are repeated. methods used in human resources. Human resources (HR) functions at its peak in the aviation industry due to both internal management aims and external environmental pressures on corporate executives to adhere to regulations.

REVIEW OF LITERATURE

Appelbaum, S. H. and Fewster, B.M. (2003) examined the field of civil aviation worldwide from the perspective of human resource management. Three audit categories—recruitment and selection, education, training and development, and organisation development—form a particularly cohesive cluster of HRM key success factors, and the paper presents the outcomes of these audits. A comprehensive audit of their organisations' HRM procedures was conducted by thirteen respondents from nine different countries, all of whom were executives from different airlines. There is a strong relationship between happy workers and world-class human resource practices, and a significant connection between happy workers and pleased customers in knowledge-based service businesses, according to the research.

Harel, G.H. and Tzafrir, S.S. (2001) looked analysed the data to see if the public and private sectors of the economy use Human Resource Management (HRM) strategies differently. Representatives from 44 percent of the companies surveyed filled out and returned 102 questionnaires. Evidence from HRM operations data was used to test the hypothesis. Since public sector organisations are heavily unionised, the authors observed that HRM domains dealing with employee selection and grievance processes get more attention from public sector managers. In contrast, private sector management places a premium on career advancement opportunities and performance-based compensation. But the authors also discovered evidence that government agencies are "moving" towards private sector models via the adoption of "high performance work practices" to conquer public demand and a tumultuous environment.

Tjiparuro, Z. (2012) researched and organised HR literature according to the three main domains: HRM, HRD, and OD. In addition, it compiled HRM, HRD, and OD fundamental ideas into a classification system; this scheme was then evaluated, and it was discovered to compare well with the People Capability Maturity Model (P-CMM), a notion recognised for greater organisational maturity. Seven top engineering and manufacturing firms in Pune, India, and fifteen human resources professionals' responses showed that the PCMM was a mystery. On the other hand, commonplace ideas like 5-S, kaizen, Sigma Six, performance management systems, employee satisfaction surveys, and ISO standards were found to have widespread support among practitioners and businesses. The methods were determined to be rooted in Deming's Plan-Do-Check-Action improvement cycle, which is the bedrock of the P-CMM.

Pillai, R. S. (2019). Increasing Productivity by Boosting Employee Engagement in India's Airline Sector. The relationship between engaged workers and productive Indian airlines is the focus of this study. It highlights how HRM strategies are crucial for improving operational results and creating an engaged workforce. Krishnan, S., & Gupta, A. (2017). Human resource management strategies and the happiness of aviation workers in India. This research delves into how HRM practices affect employee happiness, shedding light on how an engaged and enthusiastic workforce may be achieved in the Indian aviation sector via efficient HRM. Mehta (2020) cited staff turnover and retention as one of the industry's most pressing problems. It calls for a great deal of emotional



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investment. To overcome this obstacle, companies have been concentrating on making their workers happy in their jobs. Personal, social, interpersonal, and organisational aspects have all shown in research to have a substantial impact on workers' levels of job satisfaction. Satardien et al. (2019) described Opportunities for employees to make decisions on their own, have private conversations, and get positive feedback on their work are highly valued. Considering the organization's suggestions and looking into other causes other than perceived support and organisational commitment might help with this turnover. Considering the organization's high turnover rate, aviation industry stability may be enhanced by fostering organisational commitment via organisational assistance.

Statement of the Problem

Issues pertaining to gender pay gap, employee insurance, and exploitation should be brought to light in the issues statement about HRM practices at Air India. An example of a research issue introduction is provided below: Increased competition, new technologies, and new regulations are all results of the aviation industry's recent expansion and transformation in India. The importance of human resource management (HRM) techniques on job security, performance, and stability has grown in recent years. Having said that, the present evaluation of HRM practices in Indian airlines has to be finalised in order to identify important obstacles and possibilities.

Theoretical framework**Airlines industry**

The majority of Indians still can't afford to fly, hence the country's aviation sector remains underdeveloped despite its enormous untapped potential. People who work in white-collar jobs make up around 40%. If partners want to help India achieve its aviation sector goal, they need to work together and engage with policymakers to put their principles and expertise to use. India can achieve its goal of being the third biggest avionics exporter by 2025 with careful planning and unwavering commitment to quality, value, and cost efficiency. Annual passenger traffic in India reached 308.75 million in fiscal 2018, an increase of 16.52% over the previous year. Between fiscal years 2006 and 2018, the compound annual growth rate was 12.72 percent. With an anticipated rise to 293.28 million passengers in 2020, the number of domestic passengers rose 18.28% from 243 million in 2018. There was a yearly rise of 9.40% in international traffic to 1,886,630 passengers in 2017–18 and a 14.40% increase in domestic traffic to 437,930 passengers.

Human Resource Management Policies in Indian Airlines

A company's policies are its overarching rules for accomplishing its objectives. Managers should have objectives that they want to attain and procedures that they should follow to make sure they do so. Laws are "established before the goal, designed to control the activities of the enterprise and based on the main points of derived behaviour." An organization's policy is a set of rules that members must follow when faced with certain challenges. Determines the extent to which choices may be made and then watches over their implementation to make sure the company meets its goals. Consequently, the fundamental method for managing people effectively may be described as employee rules. Solid employees are necessary, and his right notion is based on the reality that the company can't reach its objectives without an environment where workers feel comfortable interacting with one another and working together. Human resource management in its whole need to be a component of personnel policy. The following are the overarching personnel regulations for all HRM tasks:

Recruitment and Promotion Policy of Indian Airlines

There have been many amendments to the Indian Air Service (General Staff) since it was first declared in Rule 32 of Part 2 of the Gazette of India on 12 March 1960. Except for flight engineers and cabin crew, all workers of Air India are legally obligated to be familiar with these regulations.

recruiting, promotion, disciplinary actions, appeals, compensation, benefits, hours worked, leaves, and recruiting perks are just a few of the numerous services that it encompasses.

Recruitment and Promotion Rules

1. All Appointments made in accordance with this policy are governed by the Service Regulation, which applies to both service personnel and aircraft engineer personnel.





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All employees should be classified in one or the other department-

- Accounting Department
- Central Tax Accounts Department
- Aircraft Engineering Department
- Transport Department
- Accounting Cost Statistics Department
- Internal Audit Department
- Material Supply Department
- General Affairs Department

2. The length of service should be in line with the duties of the position; Here are the conditions:

All four departments—Costs, Statistics, and Research Monitoring—are deemed to be part of the Ministry of Finance for the purposes of this rule.

3. Senior This level is entered by students who are at the same level. Consideration of seniority, age, experience, and field shall be given to long-term transfers across departments or fields.

4. All Posts will be filled by direct hiring, promotions, or, in the case of workers of the Indian or state governments, with the agreement of the President or CEO. Tasks requiring advancement may be filled by departmental hires or promotions from other areas, or by students in grades one through nine. Disputes involving personnel matters (such as promotions or hiring) must be resolved without delay. 6. Inadequate assistance for department heads at the executive level; The business has the right to fill vacant positions by direct hiring, promotions, other organizational means, as deemed necessary.

5. If The senior manager is not currently serving on the Committee. Disagreements over voting rights and Committee support have been reported to senior management. The report has to be examined. The Board of Directors' approval needs to be final.

General Administrative Department

Grade	Designation	Method of Appointment
Cadre-1		
I	Washer man	Direct Recruitment
Cadre-II		
I/II	Sweeper/Head Sweeper	Direct Recruitment
Cadre-III		
I/II	Gardner/Head Gardner	Direct Recruitment
Cadre-IV		
I/II	Peon/Head Peon	Direct Recruitment
Cadre-V		
I/II	Chowkidar/Guard/Durwan/Head	Direct Recruitment
Cadre-VI		
I/II	Daftry/Duplicating Operator	Direct Recruitment
Cadre-VII		
I/II	Dresser	Direct Recruitment
III/IV	Compounder	Direct Recruitment
III/IV	Nurse	Direct Recruitment
VII/VIII	Chief Compounder	Promotion
VII/VIII	Head Nurse	Direct Recruitment 25%,Promotion 75%
IX	Head Nurse	Promotion
Cadre-VIII		
III/VI	Jr. Office Asst. /Typist /Time keeper	Direct Recruitment





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VII/VIII	Office Superintendent	Direct Recruitment 25%Promotion 75%
IX	OfficeSuperintendent (S.G.)	Promotion
Cadre-IX		
III/VI	Security Asst	Direct Recruitment
VII/VIII	Security Supdt.	Direct Recruitment 25%Promotion 75%
IX	Office Superintend (s.g)	Promotion
Cadre-X		
III/VI	Tele Printer Operator	Direct Recruitment
VII/VIII	Chief Tele Printer Operator	Promotion
Cadre-XI		
III/VI	Stenographer	Direct Recruitment
VII/VIII	Confidential Stenographer	Direct Recruitment 25%Promotion 75%
IX	Confidential Stenographer (s.g)	Promotion
Cadre-XII		
III/VI	Library Assistant	Direct Recruitment
VII/VIII	Librarian	Direct Recruitment
Cadre-XIII		
III/VI	Draughtsman	Direct Recruitment
VII/VIII	Office Draughtsman	Promotion
IX	Chief Draughtsman (SG)	Promotion
Cadre-XIV		
III/VI	Telephone Operator	Direct Recruitment
VII/VIII	Chief Telephone Operator	Promotion
IX	Accounts Supdt/ Audit Supdt/	Promotion
Cadre-XV		
III/VI	Library Assistant	Direct Recruitment
VII/VIII	Librarian	Direct Recruitment
IX	Librarian (s.g)	Promotion
Cadre-XVI	Abolished	
Cadre-XVII		
III/VI	Receptionist	Direct recruitment
Cadre-XVIII		
III/VI	Stenographer	Direct recruitment
VII/VIII	Confidential Stenographer	Direct Recruitment 25%Promotio 75%
IX	Confidential Stenographer/Private Secretary (SG)	Promotion
Cadre-XIX		
VII/VIII	Examiner	Direct Recruitment
IX	Senior Examiner	Direct recruitment or Promotion

Selection from Within Indian Airlines

Applicants with passing grades (defined as 60% or above) will be appointed to the panel in ascending seniority, with seniors given precedence. The duration of service in a certain class determines the seniority of that class.





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A candidate will be considered "Excellent" if their score is 80% or greater. Appointments will be given first priority, but seniority will be taken into account when comparing them to others from the same group in the order listed on the panel.

Direct Recruitment from Outside Indian Airlines

Those applicants with the highest scores (60%) will be promoted to the top of the group according to seniority. Successful external applicants will be placed lower than internal candidates based on their scores.

1. Internal applicants with a 10/12 standard, SC/ST candidates, and ex-servicemen should be organised into separate groups according to the stipulated 30% selection.
2. The total number of applicants chosen The data supplied by the Personnel Department will form the basis for the selection groups in each of the mentioned names.
3. Following the interview, the following will be the suggestions put forward by the Selection Committee. You have two days from the time of selection to submit the survey and recommendation letter to the HR department for further processing.

Welfare Activities in Indian Airlines

Finding or supervising staff for both official and informal reasons is the responsibility of this office. Within the context of health policy, this provision permits the tracking of several behaviours. The Labour Law provides an explanation of many legislation:

- Workers' Insurance Law, 1923
- Compensation Law, 1925
- Payment of Wages, 1936
- Right to Complaint Law, 1947
- Employees' Status Insurance Law, 1948 , 1948
- Provident Fund Miscellaneous Act, 1953
- Gratuity Payment Act, 1972

In accordance with the rules set down by the Ministry of Health, Air India offers its workers a plethora of perks. Every area. Every service Whether or whether Air India's facilities double as hotels is only one of several things that will undergo periodic evaluation. Various medical facilities offered by Air India are as follows:-

Health Center

Both inpatient and outpatient therapy treatments are provided to employees at no cost. This job should be handled by trained medical professionals. Healthcare services for workers who pay a little amount into the Contribution Scheme (C.F.M.S.). Insurance coverage using the current REMS and CFMS systems. The glasses have a value of 500 rupees.

Staff Locations

You may find our staff in several major cities and train stations, including Mumbai, Kolkata, Delhi, and Chennai. The appointee will not receive any House Rent Assistance (HRA) funds, and the Authority will refund the licence cost at its discretion.

Restaurant

You may get restaurant services in Ahmedabad, Bangalore, Hyderabad, Kolkata, Chennai, and Delhi. Organisations in different sectors often get grants to bolster their operations.

Loan

Home loan: -Workers are eligible for a house loan depending on their salary after five years of service; the maximum loan amount is 2,000 Turkish Liras. Rs. 3 lakhs.





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Vehicle Loans: - Cars, scooters, and bicycles may be purchased by employees via loans that are based on their wages. Here are the details of vehicle loans:

New car	Rs.75,000
Old Car	Rs.50,000
New Scooter/ Motor Cycle	Rs.15,000
Old Scooter/ Motor Cycle	Rs.6,000
Cycle	Rs.600

Group Insurance Plan

The amount that an employee's family receives from group insurance in the event of an employee's death on the job is directly proportional to the employee's wage as of the time of death. The cost of this non-participatory approach is fifty thousand rupees (Rs.150,000).

Ward Staff Training Program

A person may serve in a maximum of two capacities for a church if they have an associate degree or above. The courses a student takes and the field of study determine the scholarship amount. Participants in the programme are those who have been with the organisation for at least a year and are eligible to receive the stipend.

Holiday Homes

Healthcare centre personnel may also take use of Air India's vacation homes. Hotel No. Resorts and tourist spots in the mountains were the sites of its construction. Rent for housing is an expense that employees must bear. Here, workers have 60 days to plan ahead and 10 days to submit their departmental benefit applications (with an additional 5 days in May and June). The resort's official airline, Air India, takes its name from the nearby airport.

Region	Name of the Station
North Region	Mussoorie, Dharamshala
South Region	Kodaikanal, Ooty
West Region	Goa, Panchgani
East Region	Puri, Gangtok

Nominal rates for Holiday Home

For Grade ½	Rs.25 per day
For Grade 3/9	Rs.35 per day
For Grade 10/12	Rs.75 per day

Three Tier Approach for Evaluation of Performance Appraisal

P.A. In the event that it receives criticism. Afterwards, the employee should get feedback on these, and a proper conversation should be had to explain the employee's loss and how the mistake will be fixed. The P.A. has to be signed by all employees and managers. Everything will be OK. A programme that offers promotions is known as the Fixed Deposit Promotion Programme. Assuming the worker has been free of criminal charges over the last three years. To verify that no wrongdoing has occurred during the last three years, you should compile an integrity and health certificate. Construct a truthful medical certificate that demonstrates his dishonesty throughout the last three years. Typically, a promotion that is applied after the fact is based on both merit and fault. If an employee is found to be lacking, their advancement will only be considered based on the report. Accounting books or yearly statements, as well as monthly statements, are the responsibility of this division. Statements of property, income, etc. The planning department has to provide the site with more personnel and monthly instructions; establish a reporting role and draft various reports.



**Darla Nagaraju and Venugopal****Protection of Company Residence**

More than three months after retiring, retirees are allowed to stay in the corporate apartment. But we won't cancel his account until after Eid.

ID Card

In order to access the IA area and have a good time on vacation, retired workers will get a unique ID card.

Training Department of Air India

Together with other departments and outside trainers, the training department plans the training. Paravartan is a company-wide initiative that Air India (IAL) has previously used to influence employee behaviour. During the course of the two days, almost three thousand employees from all around the Northern Territory were there. From its debut in 1957, when the Ministry of Commerce began offering courses in four disciplines, Air India's training and development programmes have centred on training. Later, in 1965, to address some of the requirements of workers and other economic community members, the Economic Development Corporation was founded. Business performance is impacted by the complete business training network, which is centred on commercial staff training and aircraft training for commercial personnel. In 1968, when management at Indian Airlines saw a need for this kind of training, they engaged Professor Ishwar Dayal to assess the company's requirements and design the first curriculum. According to the results of the poll, Indian airlines should train its employees in the following ways: Air India's Policy on Central Training:-

1. Check the organization's training gap and adjust to meet needs.
2. Course selection must clearly follow the criteria (A) Personal needs related to personal development. Training should continue throughout the event.
3. Provide training to all staff, including senior managers.
4. New recruits and non-commissioned officers will be released through a special induction program.
5. Experience building experience with members of other organizations.
6. Disseminate training results to the broader community.
7. Communicate Air India's plans and policies to all levels of management

Gender Pay Gap

The disparity in salary between men and women who do equivalent work is known as the gender pay gap. All around the globe, this is a major issue, but notably in the airline sector. Women only account for 3.3% of seats and 5.2% of airline CEOs, according to a study by the International Air Transport Association (IATA).

Gender Pay Gap in Indian Aviation Industry

There are several prospects in India's aviation business, which is one of the country's main industries. But the gender wage gap is still somewhat large, even if the economy is doing well.

The gender pay gap in India ranks 112th out of 153 nations, according to a research by the World Economic Forum. According to the data, women in India earn 62.5% less than males. Even the aviation sector follows this rule. Women in Aviation found that compared to male pilots, female pilots in India earn 30–40% less.

Factors Contributing to Gender Pay Gap in Indian Aviation Industry

The disparity in salary between men and women in India's aviation business has several causes. Career Opportunities in Indian Aviation Industry. Lack of female representation in leadership roles is a major contributor to this problem. Women are underrepresented in aviation's upper echelons of management and decision-making, contributing to the industry's overall male dominance. The gender wage gap is exacerbated by the fact that men and women have different roles and responsibilities in the workplace. Generally speaking, males tend to work in higher-paying occupations like drivers or managers, whilst women tend to work in lower-paying positions like housekeeping or agricultural labour.





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There is a gender wage gap, with women holding higher-paying positions. Get away from your desk and tend to your loved ones for a while. They will earn less than males in ordinary jobs since the nature of their labour is different.

Employee Protection

Even while the airline business is massive, it doesn't always translate to happy workers. American Airlines is seeing an upsurge in strikes, and according to Forbes, the staff turnover rate is close to 20%. Look at what airlines might do to boost employee retention rates in light of the perceived stress in the present economy.

Self-Employment

There should be a strong sense of community among the thousands of airline employees. It becomes simpler for managers to take care of employees when the fast-paced nature of the aviation sector brings in a huge number of workers. Airlines need to figure out how to get everyone on the same page if they want to solve their business difficulties. To do this, leaders should familiarize themselves with their team members' strengths and areas for improvement before distributing responsibilities.

Creating a Sense of Community

Airline workers need to feel like they belong somewhere, and that can only be achieved if the company fosters a stronger sense of community. Several things may be done to make this happen, such as working together regularly, choosing leaders in the community, being open and honest, and forming an organisation around the objective.

More than Salary

A competitive wage is not the deciding factor for most job candidates. Rather, they are delving into the perks offered by airlines, which implies they should start thinking about factors other than pay. A gift and reward card redeemable at over a thousand different businesses is just one example.

We Help Employees Reach their Potential

If their demands aren't addressed, most airline personnel will depart in pursuit of professional advancement. Hence, airlines should implement plans to assist their staff in realising their full potential. Anything from giving more training to giving someone more responsibility to show that they are confident might be considered. Working in an environment that challenges and develops airline personnel is common.

Communicating Transparently

Conventional wisdom held that the most effective leaders should rise to the top and work their way down. However, a lot has changed, so maybe the firm has some great ideas now. Consequently, airlines should provide a forum for staff to share their opinions and have their proposals considered. Managers should reach out to all workers who are working together to foster camaraderie if they want to see future success for their company.

Celebration

Workers want to be appreciated and recognised when they put in a lot of effort. While it's important to acknowledge workers' achievements, it's crucial to avoid showing favouritism, especially if doing so encourages everyone to work more. When everyone in the economy is in a good mood, production goes up and the economy falls.

Airline companies should realise that there is more to employment than simply generating a profit and treat their workers with dignity and respect. It is time to modernise, using the principles mentioned before as a foundation.

CONCLUSION

In both industrialized and developing nations, the ready-to-eat food market is expanding at a rapid pace. There has been a rise in the demand for ready-made meals due to changes in consumer behaviour. A lot of things in their life



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can be causing these changes. Among them, the rise of two-person or single-parent households, personal income, consumer expenditure, and the number of women in the labour force stand out as particularly significant. Thanks to innovations in healthcare, people may spend less time in the kitchen and more time on other pursuits. Shoppers are putting in less time in the kitchen and more time buying. This is due to the fact that individuals are facing a shortage of leisure time as a result of several variables, such as increased production and earnings. As a result, individuals are compelled to utilise their time to improve their financial situation and spend more quality time with their family, like in the kitchen. Consumers see the elderly as a potentially large and expanding demographic. Teens and young adults, who are often in the workforce and have a family of one or two, make up the next expanding demographic. According to the findings, one major contributor to the expansion of the fast food market is people's more hectic and demanding daily routines as a consequence of their increasingly extended work hours. The respondents, the most of whom are working women, said that they would prepare meals in advance so that they won't have to worry about cooking while they're busy.

FINDINGS

In aviation, like in many other industries, the gender wage gap is a major issue. The gender wage gap is a problem in many fields, including aviation. Businesses in India are strongly urged to follow laws that guarantee equal pay for equal work. Preferred actions included open compensation plans, equal pay regulations, and initiatives to increase diversity and inclusion. Findings from this study could provide light on unique difficulties faced by women in the aviation sector, such as low job security or stagnant professional advancement opportunities. Employees are happier and the public has a better impression of companies that make an effort to reduce the gender wage gap.

Retention and employment

Managing human resources effectively includes retaining employees, which is particularly critical in fields like aviation that need specialised knowledge and education. Competitive pay, chances for professional growth, a healthy work-life balance, and supportive management are common retention tactics. Because of the intense competition and the critical need for skilled workers, airlines may find a high turnover rate to be a problem. When people aren't happy in their jobs, they may experience stress, a lack of possibilities to advance in their careers, and an overall unhealthy work-life balance. Indian airlines may improve their staff retention rates by providing them with a positive work environment, funding their professional development, and instituting retention policies.

Recent Updates

Some things may have changed or happened in the world of business in India since I last checked in. Publications, academic research, and trade journals should be perused for up-to-date information about human resource management techniques in Indian airlines. For the most up-to-date information on gender diversity in HR, employee retention insurance, abuse at Air India, and other related topics, you should read recent academic papers, trade journals, and corporate reports. Further helpful resources include talking to HR specialists, business experts, or researchers in the field.

Suggestions

The results show that the ready meals business has a lot of room to expand. Interacting with ready-meal customers and gathering their views on the crucial missing traits was made possible by the survey. Because of this, the development stage for sellers of ready-to-eat meals will last longer, allowing them to gain the advantages of their product. It would be wise to pay greater attention to the comments and recommendations given by customers in order to encourage them to purchase ready-to-eat meals, because the majority of consumers have a good attitude towards these products.



**Darla Nagaraju and Venugopal****Discounts**

A lot of young adults and students who live on their own choose to purchase pre-packaged meals. The meal preparation firm may expand its target market beyond consumption if it meets their desire for time savings at a reasonable price. This allows the business to maintain a strong position in the fresh food sector, where ready-to-eat meals are sure to attract budget-conscious shoppers who value convenience above price.

Make it available

Important suggestions Indian businesses rely on customers' familiarity with and preference for Indian goods to drive sales, but when supplies run low, buyers will go elsewhere.

Promotion/diversity of Indian food

Another reason more people buy food is because there isn't enough variety in ready-to-eat items. Indian businesses are putting a lot of effort into finding a solution and providing more to consumers, but they need take the aforementioned suggestions into account to make it more accessible.

Product changes

Companies should lower the fat and salt level in various goods as they are aware of the many health issues that may be caused by these ingredients. They also claimed that meal prep services could make lower-fat alternatives in addition to their more dubious offerings.

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Investigate the Impact of Flexible Working Arrangements on Organizational Performance, Employee Satisfaction, and Retention, and How HR Can Balance these Needs Effectively

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ABSTRACT

New working patterns, such as flexibility, have emerged today that allow the employee free choice on where, when, and how to work. This work aims to analyze the extended effects of, and the relationship between, flexible working arrangements and organizational productivity, employees' satisfaction and turnover. Studies show that flexibility at work has a positive impact on organizational effectiveness because of increased efficiency, better work-life adjustment, and fewer sick days. Furthermore, they tend to raise the levels of employees' satisfaction because of enhanced job content control and diminished commuting pressure. However, these advantages always come with organizational requirements and meeting the desired balance and distribution among all the employees have remained a problem for HR professionals. Some of the factors that have to be considered include cohesion, control of productivity problem, and equality issues between in-office and work from home employees. Measures that include adequate communication, sound performance management systems, and effective policy enabler and execution are the keystones when it comes to getting the most out of flexible working, while avoiding the pitfalls along the way. Although this research meta-analyzes available literature, SHRM scholars may find its topical suggestions functional for understanding the opportunities and challenges that flexible working arrangements pose to working people and practicing HR practitioners. As a result of such dynamics, reading this paper shall enable the organizations enhance a positive working environment that correlates with the high satisfaction levels and long-term retention among the workers as well as boost organizational performance.





Keywords: SHRM, better work-life adjustment, organizational performance, employees' satisfaction

INTRODUCTION

Recent changes in the organization of work brought by technologies and preferences of employees to have work-life balance have also caused the emergence of FWAs. These arrangements include work from home arrangement, flexible working hours and compressed working weeks which provide employees with self-organization and flexibility as to how they balance work and other duties. Therefore, the study of FWAs and their impact on organisational performance, employees' satisfaction, and retention becomes even more important as organisations strive to gain competitive advantage and attract best talent. Teleworking capabilities are normally seen as having the possibility of enhancing organizational commitment and satisfaction due to flexibility from demands placed on an individual and strain from commuting to work. Increased satisfaction, in turn, means that employees will be less inclined to leave the company, which reduces turnover. Thus, the impact on the organizational performance gives somewhat mixed picture. On one hand, FWAs can contribute to higher productivity and innovation through increased employee motivation, but on the other hand they present certain difficulties when it comes to cohesiveness of the teams and management of their performance. Human Resources is caught between these dynamics, it tries to design and secure FWAs that serve organizational interests but also meet its employees' needs. They include the aspects of providing different lines of communication, creating proper systems of performance management, and considering possibilities of working hours' flexibility in the organization. Regarding these aspects, this research will seek to look at ways and means through which various FWAs can be instituted as well as other recommendations on how the benefits of such can be savored with least frustrations of the challenges mentioned above.

RESEARCH OBJECTIVE

- To assess the Effect of Flexible Working Arrangements on Organizational Performance
- To evaluate the Impact of Flexible Working Arrangements on Employee Satisfaction
- To investigate the Relationship Between Flexible Working Arrangements and Employee Retention
- To develop HR Strategies for Balancing Flexible Working Arrangements with Organizational Needs

RESEARCH PROBLEM

This paper aims to outline how the incorporation of flexible working arrangements (FWAs) into today's work setting has raised noticeable concerns on how it is affecting organizational performance, employee satisfaction, and retention. In the wake of organizations embracing FWAs including tele-work, flexible time, and compacted work schedules, there is a bind to examine the impact of these arrangements on different aspects of organisational life. Thus, the relationship between FWAs and OPB is still unclear although FWAs are considered to positively affect employee satisfaction, experienced decrease in work stress, and improved work-to-family conflict. The nature of the controls raised issues about productivity, team spirit and pattern of performances, all of which needs to be discussed in order to understand the effects of these arrangements. The difficulties arise in the fact how to meet organizational and business needs on the one hand, and promote FWAs on the other one. As a result, HR has to identify such effective strategies that would increase employee satisfaction and retention while at the same time meeting or surpassing the organizational performance goals needed to implement FWAs. Thus, questions such as how FWAs affect overall productivity, how it affects the retention rate of employees, and how FWAs can be effectively balanced with productivity standards fall into the key areas of concern for the management of HR. To arrest these issues, it is consequently necessary to assess the reciprocal impacts of FWAs on the organisations and employees. The following research questions shall be answered The purpose of this research is to identify all the potential effects of FWAs and proffer quantitative suggestions for the utilisation of FWAs in holistic HRM strategies by practitioners taking into consideration the organisational strategic map.





LITERATURE REVIEW

Impact of the Implementation of Flexible Working Arrangement on Organization performance

The use of FWAs has emerged as a successful organizational intervention for the changing nature of work, but the effect on organizational effectiveness and efficiency is recognized to be a complex relationship. Contemporary research on FWAs' impact on performance indicators has reported both benefits and drawbacks. On the other hand, extant literature indicates that FWAs lead to improved productivity and employee satisfaction. For instance, Bloom et al. (2019) observed that workers who were allowed to work from home delivered more and quit at a slower rate than the office workers. This improvement is sometimes explained by "reduced commuting stress and increased work autonomy positively impact job satisfaction and motivation" (Choudhury et al., 2020). Besides, FWAs can catalyse innovation since employees are able to work in contexts that are in harmony with their chronotypes (Allen et al., 2015). On the other hand, FWAs imply some challenges for organizational performance and its enhancement in particular. Some of the challenges that the employees put forward include reduced cohesiveness of the teams, lack of communication, and performance tracking problems (Gajendran & Harrison, 2007). From this, one may deduce that the physical absence can limit IMC because of the reduced ability to support teamwork and result in management issues concerning enforceability of responsibility and work productivity (Kossek & Ozeki, 1998). Hence, the enforcement of FWAs requires appropriate consideration and planning. These challenges indicate that organisations need to have sound performance management systems and also engage in efficient virtual communication. Solving these potential drawbacks, organization can utilize FWAs to improve the organizational performance and at the same time, preserve the positive team relations.

Analysing the possibility of the existence of the Relationship Between Flexible Working Arrangements and Employee Retention

Flexible working arrangements (FWAs) and its link with employees' turnover intention is one of the trending areas of research in today's organizations. LWAs like telecommuting, flexible schedules, and reduced workdays are more implemented to improve the level of the employee's contentment and decrease turnover rates. In order to understand this kind of a relationship, flexibility must be understood depending on the ways in which it influences the factors that make employees to stay or leave a given organization. Descriptive research indicates that the implementation of FWAs can have a direct impact on the levels of staff retention since it addresses issues related to job satisfaction and work life balance. Allen et al., 2015 echoed the same by pointing that for employees with workplace flexibility, they are always happier, more satisfied at their workplace, and would not want to leave their employer. This relationship is believed to be linked to flexibility that comes from these arrangements which have their effects on the stress levels and hence employee performance and retention. Nevertheless, the association is not always proactive and might differ depending on the specific organizational setting and certain employee characteristics. For instance, Choudhury, Foroughi, Larson (2020) indicates that although the FWAs might enhance retention of employees in some categories, they can as well pose some difficulties like social exclusion and communication barriers which would deter retention of the employees. Moreover, generalizability of the FWAs in achieving the retention enhancement may mute with the degree to which employees perceive these arrangements as fair and unbiased at workplaces (Gajendran & Harrison, 2007). For organizations to get the most out of FWAs on the issue of retention of employees, leaders are encouraged to apply these arrangements wisely. Positive managerial actions, which are depicted as communication, performance review, and ensuring FWAs are made available for the employees are essential if flexibility is to boost retention (Kelliher & Anderson, 2017). Thus, recognizing these factors will help organizations to closer ties between the FWAs and retention of employees.

METHODOLOGY

As a consequence, the research of the present paper uses a single quantitative research method for assessing the consequences of FWAs on organizational performance, employee satisfaction, and turnover. In the proposed study, data would be gathered through structured questionnaires administered to employees in different organizations that



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have adopted FWAs. The survey data will include quantitative data on organisational performance, job satisfaction and retention rates; objective and standardised, using reliable, valid tools. In order to process the data collected from clients/patients and their relatives, Statistical Package for the Social Sciences (SPSS) will be employed. Qualitative data will be described through basic descriptive analysis while quantitative variables will be subjected to correlation and regression analysis to test their hypothesis between FWAs and the organizational performance, employees' satisfaction, and retention. This analysis will aid in determining several important trends and associations that will allow a better understanding of FWAs' impact on these outcomes and HR's ability to manage these requirements. It will also entail comparing FWAs' perceptions with different demographics and organizational settings to gain insight into the general scope. Due to the combination of the quantitative analysis of data collected with the application of practical advice, the study will be able to provide guidelines to the elements that should be considered by the practitioners, especially the HRM ones, with the intention to make the best out of the FWAs within the organizations' frameworks.

Analysis

Demographic examination

Age

The above-demonstrated figure and table highlight the age distribution of the respondents which efficiently displays that the most frequent was the 36-45 years indicated 29.83%. Moreover, there were 19.75% more than 46 years of age, 22.22% 26-35 years of age people, and the least frequent were 8.64% of 15-25 years aged individuals.

Gender

The above table and figure show the gender of the contestants which advocates the percentage of distribution in the survey. There were 34.57% of females, 24.69% males, and 20.99% of individuals who refused to reveal their gender involved in the survey.

Designation

The above figure and tables establish the designation of the contributing professional personalities in the survey. There were 34.57% of managers, 25.93% of COO, and 19.75% of CEOs participated in the survey.

Descriptive analysis

The above table denotes the descriptive examination of the established IVs and DV. Moreover, the skewness and kurtosis values of DV are 0.297 and -1.445 respectively. However, the mean score values of the IVs are 2.17, 3.09, 2.29, and 2.48 respectively.

Regression**Hypothesis**

H1: There is a strong connection between flexible working hours and organizational performance. The above table highlights the tables of measurement for the first hypothesis showing model summary ANOVA and coefficient tables. It can be realized that the significance value is 0.058 which is around equal to the standard value of 0.05 suggesting a strong connection between flexible working hours and organizational performance.

H2: There is a significant relationship between remote work opportunities and organizational performance

The above table sheds light on the tables of measurement such as model summary, ANOVA, and coefficient table for the third hypothesis. Moreover, the R and R square values are 0.26 and 0.069. However, the significance value is 0.057 which is roughly equivalent to the standard usual value of 0.05 suggesting that there is a positive connection between the IV2 and DV.

H3: Work-life balance plays a huge role in improving the Organizational Performance. From the ANOVA table, it can be seen that the significance value is 0.050 which validates the developed hypothesis three suggesting a strong relationship between the developed dependent and independent variables.



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H4: there is a huge impact of Employee Autonomy on the performance level of the organizations. The above table sheds light on the tables of measurement such as model summary, ANOVA, and coefficient table for the fourth hypothesis. Moreover, the R and R square values are 0.47 and 0.227. However, the significance value is 0.054 which is roughly equivalent to the standard usual value of 0.05 signifying that there is a strong relationship between the IV4 and DV.

Correlation test

From the above table of correlation investigation, it can be supposed that the uppermost relation value of IV4 which is the use of technology for learning, and the value is 0.914 which is near to the standard P value of 0.9. Therefore, the developed dependent and independent variables are strongly interrelated with each other.

DISCUSSION

The introduction of FWAs in the context of organizational performance and satisfaction as well as employee's turnover involves a balance, which is quite sensitive for an organization to achieve. According to the current literature, there is an implication that implementation of FWAs will go a long way in improving the level of satisfaction of the current employees hence; increasing their retention rates. When employees do not have control over the working hours, the level of stress rises, however, the organizations that enable the employees to have control over working hours and environment see their employees job satisfaction, organizational commitment, and turnover rate decrease (Choudhury, Foroughi, & Larson, 2020). The convenience, especially in the areas of working time and location, is highly appreciated by the employees because it contributes to non-work activities, and thus affects productivity rates. However, it must be stated that the connection between the introduced FWAs and the performance of an organisation cannot be considered very direct or unambiguous. On the positive side, FWAs have additional repercussions with reference to betterment of satisfaction level of the employees and decline of turnover rates. On the other hand, FWAs have some demerits in connection to performance evaluation and team spirit. There is a possible consequence of timely usage of remote or flexible working patterns that is effective communication disruption and decrease of the six people interaction that in the opinion of Allen et al., (2015) is disadvantageous for the project results or for the final result. Adherence to the requirements will assist in preventing such adverse effects as such; On the same note, conscientious practice of the performance benchmarks and the workers' interactions with their teams is integral in preventing such negative repercussions. Relations with the staff, such as Human Resources (HR) does apply such dynamics with the intention of levelling. For this reason to a large extent FWAs need to be backed by efficiency performance set systems which HR has to implement to factor flexibility while working for the same company at the same time. This involves identification of the goals and objectives, pre-eminence of vehicle communication, and best practice of on call or Butler employment (Kelliher & Anderson, 2017). By remedying these determinates HR could enhance the positive impact of FWAs on the employee satisfaction and work retention without the ill-effects on the organizational performance.

CONCLUSION

This paper reviewed the literature on the effects of FWAs on OP, ES and retention, working with the understanding that FWA presents both opportunities and issues for today's workplaces. Numerous studies have demonstrated that FWAs produce better satisfaction and hence higher retention levels to employees due to the opportunity that grant workers the chance of having work-life balance besides the autonomy they possess that would improve job loyalty hence reducing levels of turnover in organizations. However, organizations have to overcome possible disadvantages, like the issues encountered in communication in performance management, which hinders productivity. In order to strike a proper chord between these requirements, it is imperative that HR departments put into practice strategic plans that consists of guidelines such as specific performance measures that demonstrate virtual communication proficiency as well as equal opportunities in regard to flexible working policies. In this manner, through the active control of those factors above mentioned, the organisations can gain all the pluses of





FWAs without a detriment of their performance, let alone its improvement and creation of the balanced flexibility management.

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Table:1

What is your age?				
	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	16	19.8	19.8	19.8
15-25 years	7	8.6	8.6	28.4
26-35 years	18	22.2	22.2	50.6
36-45 years	24	29.6	29.6	80.2
46 years and above	16	19.8	19.8	100.0
Total	81	100.0	100.0	

Table:2

What is your gender?				
	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	16	19.8	19.8	19.8
Female	28	34.6	34.6	54.3
Male	20	24.7	24.7	79.0
Prefer not to say	17	21.0	21.0	100.0
Total	81	100.0	100.0	

Table:3

What is your designation?				
	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	16	19.8	19.8	19.8
CEO	16	19.8	19.8	39.5
COO	21	25.9	25.9	65.4
Managers	28	34.6	34.6	100.0
Total	81	100.0	100.0	

Table:4

Descriptive Statistics									
	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
DV	65	1	3	1.65	.943	.775	.297	-1.445	.586
IV1	65	1	5	2.17	1.833	.935	.297	-1.163	.586
IV2	65	1	5	3.09	2.013	-.095	.297	-2.055	.586
IV3	65	1	5	2.29	1.378	.930	.297	-.249	.586
IV4	65	1	5	2.48	1.880	.554	.297	-1.666	.586
Valid N (listwise)	65								





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Table:5

Model Summary ^b					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.207 ^a	.043	.028	.929	2.444

a. Predictors: (Constant), IV1
b. Dependent Variable: DV

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.436	1	2.436	2.820	.058 ^b
	Residual	54.426	63	.864		
	Total	56.862	64			

a. Dependent Variable: DV
b. Predictors: (Constant), IV1

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.415	.179		7.889	.000
	IV1	.106	.063	.207	1.679	.058

a. Dependent Variable: DV

Table:6

Model Summary ^b					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.262 ^a	.069	.054	.917	2.790

a. Predictors: (Constant), IV2
b. Dependent Variable: DV

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.917	1	3.917	4.660	.055 ^b
	Residual	52.945	63	.840		
	Total	56.862	64			

a. Dependent Variable: DV
b. Predictors: (Constant), IV2

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.026	.210		9.670	.000
	IV2	-.123	.057	-.262	-2.159	.057

a. Dependent Variable: DV





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Table:7

Model Summary ^a					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.476 ^a	.227	.215	.835	1.825

a. Predictors: (Constant), IV4
b. Dependent Variable: DV

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.905	1	12.905	18.496	.054 ^b
	Residual	43.956	63	.698		
	Total	56.862	64			

a. Dependent Variable: DV
b. Predictors: (Constant), IV4

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.236	.172		12.994	.000
	IV4	-.239	.056	-.476	-4.301	.054

a. Dependent Variable: DV

Table:8

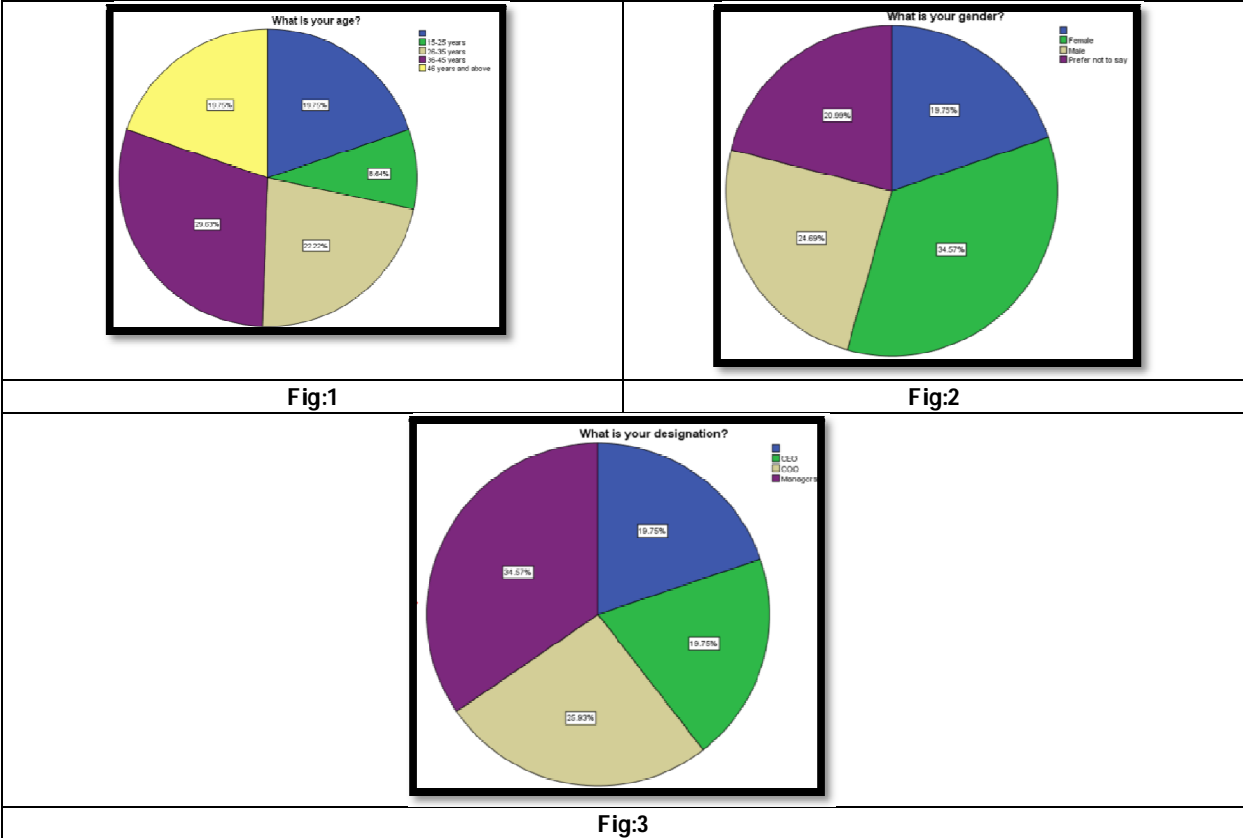
Correlations						
		DV	IV1	IV2	IV3	IV4
DV	Pearson Correlation	1	.207	.962	.537 ^{**}	0.9822 ^{**}
	Sig. (2-tailed)		.098	.035	.000	.000
	N	65	65	65	65	65
IV1	Pearson Correlation	.207	1	-.199	.382 ^{**}	-.219
	Sig. (2-tailed)	.098		.112	.002	.080
	N	65	65	65	65	65
IV2	Pearson Correlation	-.262 ^{**}	-.199	1	-.201	.029
	Sig. (2-tailed)	.035	.112		.108	.816
	N	65	65	65	65	65
IV3	Pearson Correlation	-.437 ^{**}	.382 ^{**}	-.201	1	-.097
	Sig. (2-tailed)	.000	.002	.108		.443
	N	65	65	65	65	65
IV4	Pearson Correlation	-.476 ^{**}	-.219	.029	-.097	1
	Sig. (2-tailed)	.000	.080	.816	.443	
	N	65	65	65	65	65

^{*}. Correlation is significant at the 0.05 level (2-tailed).
^{**}. Correlation is significant at the 0.01 level (2-tailed).





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The Role of Board of Directors in Cooperative Administration with Special Reference to Primary Agricultural Credit Cooperative Societies in Cuddalore District - A Study

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ABSTRACT

In rural areas, the Primary Agricultural Cooperative Society (PACS) is crucial for the growth of the agricultural sector. PACS provides necessary services, such as agricultural services, financial inclusion services, e-mobility and smart products, PDS services, and other services, to those needy people at the right time and only for the goal of servicing people. As an example, the PACS acting as a bridge between farmers and the government. PACS is the root of every scheme implemented by both the central and state governments. The Cooperatives are functioning at cross root level and also under prescribed principles which are reformulated by ICA. Cooperatives is not a separate owner entity organisation. In this regard, "member can become an owner than owner can become a member". However, the owner of members are not concentrating fully for the betterment of cooperatives in India. Even though the futures are available in the cooperative organizations, they are not able to function well due to lack of members and board of directors participation. The results indicate that due to lack of skills and knowledge, the board members' are not able to lead the cooperatives effectively. The effectiveness of a board is heavily influenced by its leadership, communication, accountability, and ways of making decisions. Higher effectiveness is related to a style of management that transforms which is characterized by empathy, trust, and open communication. The study highlights the need of board member capacity-building initiatives that emphasize communication, focusing on leadership skills, and decision-making. The study additionally recommends that PACS take a more participatory approach when making decisions, involving stakeholders and members in the process. The author suggests that implications for the Cuddalore District's PACS. Overall, this study provides valuable insights into the role of the board of directors in the

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leadership of a PACS and highlights the importance of effective leadership in promoting the success of these organization.

Keywords: Leadership, Board of Directors, Accountability, Governance, Management, Leadership style, Effectiveness, International Cooperative Alliance (ICA).

INTRODUCTION

According to the International Cooperative Alliance, by supporting local communities, fostering equity in society, and promoting sustainable agriculture, cooperatives have the potential to improve the livelihoods of billions of people around the world. In cooperatives, the board is in responsible for setting up the overall direction and strategy of the organization, overseeing its day-to-day operations, and making important decisions that impact the success of the organization. **At the highest decision making body in the cooperatives, the Board of Directors leadership is essential in fostering a culture of transparency, accountability, and member participation. Effective leadership by the board of directors can lead to increased efficiency, improved member satisfaction, and enhanced reputation for the cooperative.**

Role and Responsibility of Board of Directors

1. Overall Governance: The Board of Directors is in responsible for setting the cooperative society's overall direction and strategy and making sure that it is consistent with the organization's mission, values, and goals.
2. Policy Making: The Board sets the rules and guidelines that govern the cooperative's operations, ensuring that they are fair, transparent, and represent the needs of the members.
3. Strategic Planning: To ensure sure the cooperative is well-positioned for achieving its goals and objectives, the Board develops and reviews strategic plans.
4. Financial Management: The Board is in responsibility of the cooperative's finances and makes ensuring that it makes prudent and responsible financial decisions.
5. Risk Management: The Board oversees and regulates risks that could impact the cooperative's financial performance, reputation, or day-to-day operations.
6. Governance and Compliance: The Board ensures that the cooperative complies by all relevant regulations, laws, and standards and that its governance practices are transparent and accountable.
7. Member Engagement: The Board engages with members, focusing attention to their issues and ensuring their voices are heard.

REVIEW OF LITERATURE

The researcher reviewed 20 number of literature related to the study, at the same time a minimum no.of literature related to the study which are given below. On the basis of the review done, it was understood that the present research is clearly with a different line of thinking and approach to highlight the Cooperative Governance in the Cuddalore District in Tamilnadu. Relevant literature in Role of Board of Directors is reviewed in this section in order to identify research gap in the field. **Singh and Prathap 1985** – Education is essential for self-control, supervision, and better and successful utilization of cooperative credit in cooperative education. Political intervention in recovery matters should also be reduced, as highly qualified and experienced staff may considerably reduce the adverse impacts of such interface on recovery outcomes. **Ahmed et al., 2016** –A crucial factor in cooperative societies' success is the Board of Directors' leadership. According to the author perspective, accountability, transparency, and strong governance are characteristics of good leadership.



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Mwangi et al., 2017 – The leadership of the Board of Directors is also influenced by the role played by stakeholders. The study found that stakeholder engagement and participation can enhance the effectiveness of cooperative leadership. **Abubakar et al. 2017** – Members of the Primary Agricultural Cooperative Society also shared their thoughts on the effectiveness of their board of directors. According to a study, members believed the cooperative's ability to make decisions in an accountable and transparent manner depended on having a strong Board of Directors. **Wahab et al., 2018** – The personalities and behaviours of each board member have an influence on the board of directors' leadership as well. According to this study, the personal beliefs, attitudes, and behaviours of board members significantly predict their cooperative performance. **Abubakar et al. 2019** – To ensure PACS's success and build member trust, accountability and transparency are important. Regular financial reporting and open communication were considered to be essential for upholding accountability and transparency within the cooperative.

Research Gap

There is a need to develop in more number of aspects in the study area Cuddalore District. Which are relating to the Board of Directors in Primary Agricultural Cooperative Societies. The effects of digital transformation, gender diversity, training and development, Awareness and educational programs, involvement of stakeholders, and the long-term impact of leadership styles are a few of these. Despite the fact that men represent the majority of the board, the study did not examine the potential effects of more gender diversity on processes for making decisions, the effectiveness of leadership, and cooperative results. Furthermore, an ongoing study of the ways in which different styles of leadership influence PACS's sustainable growth and performance has been excluded from the study. Filling in these gaps could provide to a more thorough knowledge of the factors affecting PACS sustainability and effectiveness.

Statement of Problem

The leadership of a Primary Agricultural Cooperative Society is important for its success. Even though such significance are available, due to different opinion of both cooperative and Board of Directors, lack of education and skills, weak governance practices, lack of transparency, and accountability can lead to mismanagement and conflicts within the cooperative societies. Inadequacy of leadership quality in the PACS which in turn affects the development of the society. So in the line of thinking, the researcher wanted to study the enhancement of leadership effectiveness of Board of Directors in the PACS.

Objectives of the Study

1. To study the level of Board of Directors participation in the study area in Primary Agricultural Cooperative Society.
2. To access the member satisfaction about the Board of Directors services in Cuddalore District.
3. To find out the suitable solution for the betterment of PACS in the study area.

RESEARCH METHODOLOGY

The present study is based on both Primary and Secondary data. The primary data is collected from the Board of Directors and members by interview schedule of the PACS in the Cuddalore District and Secondary data is collected from the various books, journal, articles and websites relating to PACS. The Primary Agricultural Credit Cooperative Society working under Cuddalore district is divided into 3 circle viz., Cuddalore, Chidambaram, and Viruthachalam. Cuddalore circle consisting 4 blocks, Chidambaram circle consisting 5 blocks and Viruthachalam circle consisting 4 blocks. Chidambaram circle under 57 PACS, Cuddalore circle under 56 PACS and Viruthachalam circle under 46 PACS. Totally, 159 PACS are working in Cuddalore District. The researcher chosen 56 PACS from each block 4 societies undertaken on the year of establishment. Each Five respondents from each society as a Members and 3 from each society have been selected respondents are Board of Directors. Totally, Members are 280 and Board of Directors are 112 respondents. Out of 392 interview schedules, only 92 were answered fully by the



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Board of Directors and 268 by Members, resulting in 360 respondents being chosen for the researcher. Proportionate Stratified Random Sampling method was chosen for the selection of proper sampling frame of the study for collecting in the PACS. Sample size mentioned in below Table 1.

Tools of Analysis

The researcher have been used Percentage Analysis for this Study

Data Analysis and Interpretation

It is observed from the below table that out of 100 respondents, there are 6 respondents from the age group of 18 -20 years, 13 per cent of the respondents belongs to 21 – 30 years, 10 per cent of the respondents are from 31 – 40 years, 35 per cent of the respondents belongs to 41 – 50 years, 7 per the age group of 51 – 60 years. 27 respondents are belongs to the age group of above 60 years. It is inferred from the below table that majority (35 per cent) of the respondents belonged to the age group of 41-50 years years which shows that cooperative society is has more board of directors from the above age category. It is observed from the below figure that out of 100 respondents, 74 per cent of the respondents belongs to male and 26 per cent of the respondents belongs to female gender. It is inferred from the below table that majority (74 per cent) of the respondents belonged to male gender which shows that cooperative society has more male members than female gender.

Awareness among Board of Directors about Cooperative Society

The Researcher wanted to know the role and level of awareness about Board of Directors in Cooperatives. In few aspects, which are given below.

Principles of Cooperation

In the Table 4 clearly explained about that the understanding level of cooperative principles by the Board of Directors. According to the Table majority out of 92 respondents, 96 per cent (88) respondents said No about the Principles of Cooperation. And out of 92 a megar, 4 per cent (4) respondents only Aware about the recent principles which are reformulated by the ICA.

Significance of By-laws: In the below Table indicates that Significance level of By-laws by the Board of Directors, out of 92 respondents, 93 per cent (86) respondents are not aware of the Significance of By-laws, and remaining 7 per cent (6) respondents are aware of the by-laws are followed by the Cooperative Society as per the Guidelines.

Significance of Cooperative Movement

In the below Table 4 revealed that Significance of Cooperative Movement by the Board of Directors, out of 92 respondents, 80 per cent (74) respondents are not aware of the Significance about the Cooperative Movement, and remaining 20 per cent (18) respondents are aware of the cooperative movement which is access by the government.

Getting Proper Rights in Cooperative Society

Table 4 despicts that getting proper rights in cooperative society, Out of 92 respondents, 13 per cent (12) of respondents are aware, and remaining 87 per cent (80) of the respondents are not aware about their rights within the cooperative society.

Attending Board of Directors and General Body Meetings Regularly

Table 4 shows that attending Board of Directors and General Body meeting regularly, Out of 92 respondents, this aspect has a relatively higher awareness, with 42 per cent (39) respondents are regularly attending meetings, while 58 per cent (53) of the directors are not aware about attending the general body meeting. The data indicates a general lack of awareness among the board members about the fundamental principles, by-laws, and the overall significance of the cooperative movement. This lack of knowledge could impede effective governance and the functioning of the cooperative society. The highest level of engagement is in attending meetings, yet more than half still do not attend regularly.



**Padhmanaban and Arthi****Board of Directors Services in Members View**

The Researcher collected the necessary information as under about Board of Directors services in members view. In few aspects, which are given below.

Participating in General Body Meetings

Table 5 reveals that participating in General Body Meeting, Out of 268 respondents, only 23 per cent (61) of the respondents participating in the general body meeting, and remaining 77 per cent (207) of the respondents are do not participating the general body meeting.

Sanctioning Agricultural Loans on Time

The table 5 indicates the sanctioning agricultural loans on the time in cooperative society. 27 per cent (72) of respondents are said yes of the loans are sanctioned on time in the cooperative society, compared to 73 per cent (196) of the respondents are said no for loans are not sanctioned on the right time.

Rights to Take Xerox Copies of Records

Table 5 explains that a very small proportion 3 per cent (9) of the respondents said yes that taking Xerox copy of records in the cooperative society, whereas 97 per cent (259) of the respondents said no to that in cooperative they are not allowing to take Xerox copy of the records.

Rights to participate in the Welfare of the Society

The below table revealed that welfare of the society, out of 268 respondents, 22 per cent (8) of members feel they have the rights, and remaining 92 per cent (246) of the respondents are said no for that they did not have a rights to participate in the welfare of the society.

Equality among Members

Table 5 shows that equality among members, out of 268 respondents, 19 per cent of (51) respondents are said yes for there is a equality between members, and remaining 81 per cent (217) of the respondents are said no for equality among members.

Political Influence

From the below table it can understood that out of 268 respondents, 29 per cent (79) of the respondents are said there is no political influence in cooperative society, whereas 71 per cent (189) of the respondents are believe there is more political influence in the cooperative society.

Accountability and Transparency

Table 5 clearly shows that, 18 per cent (47) of the members said yes to there is accountability and transparency, while 82 per cent (221) of the members are said no for accountability and transparency in cooperative society. The data indicates dissatisfaction among members regarding their rights and services provided by the Board of Directors. Issues such as lack of participation in meetings, delayed loan sanctioning, limited rights to access records, low participation in welfare activities, perceived inequality, political influence, and a lack of accountability and transparency are prominent concerns.

Level of Member Satisfaction about Board of Directors Services

The researcher could like to study in detailed manner about opinion regarding Board of Director in cooperative society in select aspects viz, Participating in General Body Meeting, Sanction the Agricultural Loan in Time, Rights to Take Xerox Copies of Records, Rights to participate in the Welfare of the Society, Equality among Members, Political Influence, Accountability and Transparency. It observed from the Figure 2 out of 268 members, 13 per cent of respondents are highly satisfied about the board of directors services, 11 per cent of the respondents are satisfied, 16 per cent of the respondents rate the services as average, 36 per cent of the respondents rate the services as poor, 24 per cent of the respondents mentioned that the services are very poor. The overall satisfaction with the Board of



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Directors' services is notably low. A combined 60 of the respondents rate the services as either poor or very poor, indicating widespread dissatisfaction. Only a small fraction of the respondents are highly satisfied or satisfied with the services provided by the board, reflecting potential issues in governance, service delivery, and overall board effectiveness.

Economic Contribution of Board of Directors in Cooperatives

The Researcher collected the necessary information as under about Economic Contribution of Board of Directors in Cooperatives. The researcher would like to study, regarding the director's economic participation (member economic participation) as per 3rd reformulated principles of cooperation by ICA. According to the table, the maximum number of Board of Directors 46 out of 92, 50 per cent of Board of Directors contributed economic wise very less, 33 per cent of the respondents holding 11 to 20 shares, only 3 – 10 respondents are holding above 30 shares which is high.

FINDINGS

1. Out of 92 respondents, the majority 35 per cent of the board members belong to the 41-50 years age group, indicating that the cooperative society tends to have more experienced individuals in the middle-age range in leadership positions.
2. Regularly attend meetings.
3. The majority of members do not participate in general body meeting
4. The total number of respondents are 92, 74 per cent of the board members are male, reflecting a gender imbalance in the leadership of the cooperative society.
5. Out of 268 respondents, only 4 per cent of the respondents are aware of the principles of cooperation, 7 per cent of the directors are understand the significance of by-laws, (20 per cent) of the directors are aware of the cooperative movement's significance, 13 per cent of respondents are aware of their rights within the cooperative society, 42 per cent regularly attending meetings, There is a significant lack of awareness among the board members regarding key aspects of cooperative principles and governance. Only a small fraction s and feel that their rights are not adequately upheld. There is also a perceived lack of equality, accountability, and transparency within the cooperative society.
6. 97 respondents are dissatisfied, with 36 per cent rating the services as Poor and 24 per cent as Very Poor, 16 per cent of respondents rated the services as Average, indicating ambivalence, Only 24 per cent of respondents are satisfied, with 13 per cent Highly Satisfied and 11 per cent are Satisfied.
7. Majority of 46 respondents out of 92, 50 per cent of Board of Directors contributed economic wise very less, 33 per cent of the respondents holding 11 to 20 shares, only 3 – 10 respondents are holding above 30 shares which is high.

SUGGESTIONS

1. The society should take necessary steps to motivate and admit more youth in cooperatives with the help of create awareness about the significance of cooperative movement.
2. The cooperative organisation and government should provide necessary awareness programs through cooperative education and training to the Board of Directors for the betterment of cooperative societies. Without knowing the basic aspects of cooperatives they do not function well. The only organisation functioning under prescribed principles. The member and directors should know the basic principles of cooperation, significance of bylaws, significance of cooperative movement, getting proper rights, attending Board of Directors and General Body Meeting.
3. The government and non-government organisation should provide compulsory awareness program about the features, significance and benefits, with the help of distribution of bit notice, conducting workshop, seminar, symposium, orientation and refresher course.



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4. The government and cooperative organisation should conduct periodical evaluation about the performance of Board of Directors.
5. The Board of Director should involve themselves as per the 3rd principles of cooperation they have to contribute more in economic like, buy more shares, deposit in more.
6. The Board of Directors, voluntarily involve themselves to motivate the members and provide all facilitate and benefits which are available in the societies namely (viz) to sanction loan as early as possible, make arrangements to visit frequently, verify the records, create transparency, accountability and trustworthiness also.
7. The cooperatives organisation entirely service oriented and also there is no separate owners entity (owner can become a member, member can become an owner). In this present situation, 71 per cent of the Board of Directors depended on political influences that should be avoided and also eradicate the political influence in the cooperative administration.

CONCLUSION

The study highlights in various aspects of Board of Directors about the level of participation, without member nothing can be done properly and also not able to achieve the goals. Good planning, transparency, accountability, innovation and to ensure the sustainability in cooperatives. This study provides valuable insights into the importance of effective leadership in the Board of Directors of a cooperative society. The author suggests that leaders who are able to foster a culture of trust, transparency, accountability and innovation and who are able to develop and implement effective strategies for challenges, are more likely to be successful in leading the cooperatives.

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Table 01 CUDDALORE DISTRICT

CHIDAMBARAM CIRCLE		CUDDALORE CIRCLE		VIRUDDACHALAM CIRCLE	
Rayanallur PACS (30.01.1968)	Kattumannarkovil	Vazhisothanaipalayam (30.9.1963)	Cuddalore	Sathiyavadi (04.12.1967)	Viruddachalam
Movur PACS (6.2.1968)		Vadapuram Keelapathy (19.1.1967)		Edachithur (4.12.1967)	
Eyyalur PACS (23.7.1971)		Maruthadu (10.1.1970)		Ko. Pavazhangudi (29.6.1971)	
Kuppanakuzhi PACS (9.8.1971)		Sigirikudi (23.6.1970)		Aladi (29.6.1971)	
Sivayam (2.8.1967)	Kumarachi	Kurinjipadi (7.10.1957)	Kurinjipadi	V. Sathapadi (31.3.1963)	Kammapuram
Nandhimangalam (2.8.1967)		Renganathapuram (20.1.1968)		Devangudi (20.1.1968)	
Lalpettai (23.2.1971)		Theerthanagiri (29.12.1970)		V. Sathamangalam (25.11.1969)	
Pillayarthangal (11.1.1971)		Kayalpattu (18.4.1972)		Mudhanai (22.12.1969)	
Thillavidagam PACS (30.6.1967)	Parangipettai	Veeraperumanallur (7.10.1957)	Panruti	11525 Tholudur (12.4.1967)	Mangalur
Poovalai PACS (19.8.1967)		Anguchettipalayam (30.9.1967)		11529 Adarikalathur (20.1.1968)	
Keezhamanakudi PACS (19.6.1967)		Patharakottai (11.6.2014)		CLAPLn02 (23.6.1972)	
Pichavaram PACS (17.12.1970)		Silaminathanpettai (11.6.2014)		SPLn01 Edaicheruvai (23.8.1972)	
Majakollai (21.1.1965)	Bhuvanagiri	Aviyanur (31.8.1958)	Annagramam	Veppur (14.2.1967)	Nallur
Erumbur (28.1.1968)		Thirukandeswaram (20.1.1968)		V. Gudalur (30.1.1968)	
b.Udaiyur (24.7.1971)		Keelkavarapattu (23.3.1970)		Maligaimedu (28.9.2969)	
Valayamadevi (23.1.1971)		Melkumaramangalam (23.1.1973)		Maligaikottam (12.5.1982)	
C. Orathur (18.9.1958)	Keerapalayam				
Sakkandgudi (27.1.1967)					
Vilagam (21.2.1970)					
Velliyakudi (19.1.1971)					
Perur (30.1.1968)	Srimushnam				
Nantheeswaramangalam (20.8.1968)					
Mudikandanallur (23.8.1968)					
Palayankottai (29.12.1970)					





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Table 2. Age wise Classification of Board of Directors of PACS

Sl. No	Age	No.of Respondents	Percentage
1	18-20 years	6	6
2	21-30 years	12	13
3	31-40 years	9	10
4	41-50 years	32	35
5	51-60 years	6	7
6	Above 60 years	27	29
	Total	92	100

Source: Computed from Primary data

Table 3 Awareness among Board of Directors about Cooperative Society

Sl. No	Awareness among Board of Directors	No.of Respondents		Percentage
		Yes	No	%
1	Principles of Cooperation	4 (4%)	88 (96%)	92 (100%)
2	Significance of By - laws	6 (7%)	86 (93%)	92 (100%)
3	Significance of Cooperative Movement	18 (20%)	74 (80%)	92 (100%)
4	Getting Proper Rights in Cooperative Society	12 (13%)	80 (87%)	92 (100%)
5	Attending Board of Directors and General Body Meeting regularly	39 (42%)	53 (58%)	92 (100%)

Source: Computed from Primary data

Table 4. Board of Directors Services in Members View

Sl. No	Members Rights	No.of Respondents		Percentage
		Yes	No	%
1	Participating in General Body Meeting	61 (23%)	207 (77%)	268 (100%)
2	Sanction the Agricultural Loan in Time	72 (27%)	196 (73%)	268 (100%)
3	Rights to take Xerox copy of record	9 (3%)	259 (97%)	268 (100%)
4	Rights to participate in the welfare of the society	22 (8%)	246 (92%)	268 (100%)
5	Equality among Members	51 (19%)	217 (81%)	268 (100%)
6	Political Influence	189 (71%)	79 (29%)	268 (100%)
7	Accountability and Transparency	47 (18%)	221 (82%)	268 (100%)

Source: Computed from Primary data

Table 5 Economic Contribution of Board of Directors in Cooperatives

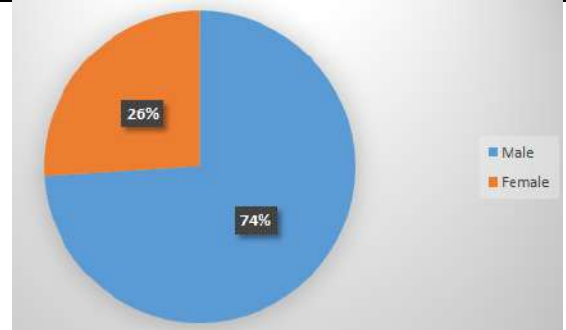
Sl. No	No. of Shares	No.of Board of Directors	Percentage
1	1 - 10	46	50
2	11 - 20	30	33
3	21 - 30	9	10
4	31 - 40	3	3
5	41 - 50	4	4
6	51 - 60	NIL	-
	Total	92	100

Source: Computed from Primary data



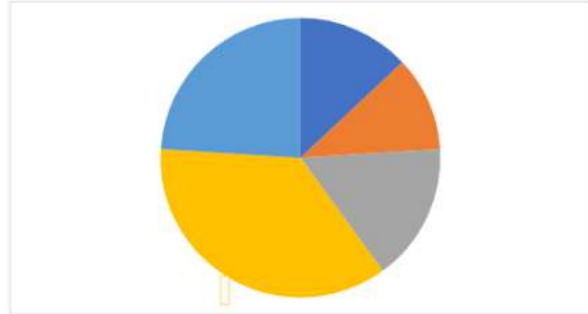


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Source: Computed from Primary data

Figure 1: Gender wise Classification of Board of Directors of PACS



Source: Computed from Primary data

Figure 2: Level of Member Satisfaction about Board of Directors Services





An UPLC Stability Indicating Method for Quantification of Elvitegravir, Tenofovir Alafenamide Fumarate, Emtricitabine and Cobicistat in their Fixed Dose Combination

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ABSTRACT

A stability indicating analytical method for estimation of analytes in bulk and/or dosage forms allows the analyst to quantify the analytes even in the presence of degradants. The main focus of present research work is to develop and validate a stability indicating method for simultaneous estimation of selected drugs elvitegravir, tenofovir alafenamide fumarate, emtricitabine and Cobicistat in their fixed dosage forms using acquity UPLC-PDA system. The analytes were successfully quantified on BEH C18, Acetonitrile and 0.1% orthophosphoric acid (55:45%v/v) as mobile phase at a flow rate of 0.2ml/min at 248nm. The run time of analysis is less than 3mins with retention times and linearity ranges of analytes as 0.403min, 37.50-225 µg/mL; 1.028 min, 2.5-15 µg/mL; 1.464 min, 50-300 µg/mL & 2.122 min, 37.50-225 µg/mL for Elvitegravir, Tenofovir, Emtricitabine and Cobicistat respectively. Statistical analysis of validation parameters data were within the acceptable limits indicating the suitability of the method for the routine quantification of analytes in the dosage form.

Keywords: Elvitegravir, Tenofovir Alafenamide Fumarate, Emtricitabine, Cobicistat, UPLC, Stability indicating.



**Divya Narla and Nagaraju Pappula****INTRODUCTION**

Antiretroviral therapy (ART) is a strategic treatment for Human Immunodeficiency Virus (HIV) infection. ART is initiated after early diagnosis of HIV which includes oral therapy with combination of multiple drugs in fixed dose[1]. Fixed dose combinations (FDC's) enhance the efficacy and reduce the pill burden for the patients. Fixed dose combinations in ART contain protease inhibitors (PI), nucleoside transcriptase inhibitors (NRTI's), non-nucleoside transcriptase inhibitors (NNRTI's), integrase strand inhibitors[2]. Pharmacokinetic enhancers may be included to improve the bioavailability of ART drugs[3]. A fixed dose combination of Elvitegravir (ELV). Tenofovir alafenamide fumarate (TAF), Emtricitabine (ETC) and Cobicistat (CBS) is approved by USFDA for HIV treatment in adults and adolescents[4]. Elvitegravir is a potent integrase strand inhibitor having strong anti HIV activity against wild and drug resistant HIV strains[5]. It prevents viral replication by inhibiting the integration of viral DNA into host cell[6]. Tenofovir alafenamide fumarate, a prodrug of Tenofovir, shows 10times more antiviral activity than Tenofovir disoproxil fumarate[7]. It belongs to NNRTI class and is used in FDC's for treating HIV infection[8]. Emtricitabine is NRTI antiretroviral compound whose active metabolite incorporates into viral DNA and terminates the synthesis of viral DNA[9,10]. Cobicistat devoids antiviral activity but is a part of FDC as it acts as booster (pharmacokinetic enhancer) to enhance the plasma concentrations of primary active drugs acting against HIV[11]. It acts by inhibiting Cytochrome P450 enzyme which extensively metabolizes Elvitegravir. Cobicistat in FDC's of ART increases drug exposure thereby reducing pill burden[12]. The chemical structures of the selected drugs was shown in Figure 1. Literature review on the afore mentioned combination for analytical research was extensively done, which showed a handful of HPLC[13-18] and few UPLC[20-24] methods reported for combination of Elvitegravir, Tenofovir disoproxil fumarate, Emtricitabine and Cobicistat. As there is no UPLC method for estimation of FDC consisting of Elvitegravir, Tenofovir alafenamide fumarate, Emtricitabine and Cobicistat, there is scope for developing a newer analytical technique. The present stability indicating UPLC method was developed to provide a sensitive, accurate and reliable method for routine quantification of selected analytes in their marketed commercial formulation.

MATERIALS AND METHODS**Reagents and Chemicals**

Reference standards of Elvitegravir, Tenofovir Alafenamide fumarate, Emtricitabine and Cobicistat were obtained as gift samples from Hetero Labs, Hyderabad and Aurobindo Pharmaceuticals, Visakhapatnam. The fixed dose generic product of Elvitegravir-150mg, Tenofovir alafenamide fumarate -10mg, Emtricitabine-200mg and Cobicistat-150mg was procured from commercial source. Chromatographic grade solvents Acetonitrile, Methanol, Water and Analytical Grade reagents ortho phosphoric acid, Potassium dihydrogen phosphate, Hydrochloric acid, Sodium Hydroxide and Hydrogen peroxide were used for the present work and are procured from Merck Ltd and Thermo Fisher Scientific.

Instrumentation and Chromatographic conditions

The ultra performance liquid chromatographic analysis for determination of selected analytes was performed on UPLC (waters acquity) equipped with PDA detector, quaternary pump and an inbuilt injector operated through Empower 2 software. Additional equipment included Electronic balance (Shimadzu), pH meter, ultra bath Sonicator, UV chamber, Hot air oven were used in the present study. The separation and quantification of analytes in the fixed dose combination was achieved on BEH C18 column (100×2.1mm,1.8µm) with 1.0ml/min of mobile phase (acetonitrile and 0.1%OPA in ratio of 55:45v/v) at 265nm for detection of analytes. The sample size is 0.5 µl with runtime of 3mins.



**Divya Narla and Nagaraju Pappula****Preparation of standard solution**

The reference standards of 75mg of ELV, 5mg of TAF, 100mg of ETC and 75mg of CBS were accurately weighed and dissolved in sufficient quantity of diluent (Acetonitrile and 0.1%OPA in 1:1 ratio) in a 100ml volumetric flask. Final stock solution was obtained after sonication and making the volume. The standard solution for analysis was prepared by further dilution of suitable aliquot of stock solution to obtain required concentration with diluent.

Preparation of sample solution

The tablets of commercial dosage form were used to prepare sample solution. Finely crushed tablet powder equal to half weight of tablet was added to 100ml flask, dissolved, sonicated in diluent followed by vacuum filtration to obtain sample stock solution, which is further diluted to give working sample solution.

Method validation

The developed stability indicating UPLC method was validated according to the ICH guidelines for all the specified parameters such as specificity, system suitability, linearity, precision, accuracy including robustness, limit of detection (LOD) and limit of quantification (LOQ) [13].

System Suitability

The standard solutions were injected in triplicate into the UPLC system and the system suitability parameters were evaluated such as theoretical plates, tailing factor and resolution. Each parameter has its specified role in establishing the suitability of the method for the quantification of analytes.

The number of theoretical plates indicates the efficiency of the column and plate count value of more than 2000 is acceptable. Tailing factor of chromatographic peak reflects the symmetry of the peak, whose value should be close to 1. Resolution is a measure of how well the analyte peaks were separated from each other and its specified value is greater than 2.0.

Specificity

The specificity of the developed method is assessed by looking for the presence of additional peaks in the chromatograms of blank and placebo. Method specificity is indicated by the absence of these additional peaks at the analyte retention times in the chromatogram.

Linearity

Calibration curves are plotted to know the concentration ranges of each individual analyte from the value of correlation coefficient. The plot is obtained by taking concentration on ordinate and mean peak area on abscissa. Triplicates of six different concentrations were prepared for injecting into UPLC system and their peak areas are averaged to plot linearity curve.

Precision

Precision of the developed method was determined by performing system precision, method precision and intermediate precision. In system precision (repeatability) six replicates of standard solution were injected and percentage relative standard deviation for peak areas is calculated. For method precision, sample solutions (n=6) were injected and the assay values were determined. Intermediate precision was carried out on two different days under the same experimental conditions using same solutions (n=6). The %RSD values within acceptable range ensure the reliability and consistency of the developed analytical method.

Accuracy

Recovery studies were done to establish the accuracy of the developed UPLC method. The sample solutions at three different levels such as 50%, 100% & 150% of the target assay were prepared in triplicate and are analyzed by standard addition method. The percentage recovery at each level was calculated.



**Divya Narla and Nagaraju Pappula****LOD & LOQ**

The LOD and LOQ values of the developed method were determined by calibration curve method, where the standard deviation and slope values are used to calculate the LOD & LOQ values.

$$LOD = \frac{3.3\sigma}{s} \qquad LOQ = \frac{10\sigma}{s}$$

Where, σ = standard deviation of intercept; s = slope of calibration curve

LOD and LOQ represent the lowest concentrations of analyte that can be detected and quantified with certainty indicating sensitivity of the method.

Robustness

Deliberate changes in chromatographic conditions were made and their effect was studied on system suitability parameters to determine whether the method is robust or not. Mobile phase composition was varied at $\pm 5\%$ and flow rate at ± 0.1 ml/min to evaluate the tolerance of the method. The impact of the variables on chromatographic parameters such as resolution, peak symmetry, theoretical plates, retention times of analytes were evaluated. The measured values within acceptable limits indicate robustness of the method.

Forced degradation studies

Forced degradation or stress studies were carried out to induce degradation of analytes under specific conditions. The analytes are exposed to various conditions of stress to produce possible degradants which can be separated and quantified in the presence of analytes without interference. The studies were done by subjecting the analytes to undergo hydrolysis in acid, base, water and peroxide solutions; exposing to UV light and high temperature. Acid, alkali, peroxide and neutral hydrolysis was carried out by reflexing the standard solution with 0.1N HCl, 0.1N NaOH, 10% H₂O₂ and water at 60°C for 30mins. Dry heat degradation was done by placing the solution containing analytes in hot air oven at 105°C for 6hrs and photo degradation by exposing to UV light for 7days. The analyte solutions were then diluted and injected into UPLC system and the chromatograms were evaluated.

RESULTS

The developed stability indicating RP-UPLC method was validated according to ICH guidelines for the chromatographic parameters such as Specificity, System Suitability, Linearity, Accuracy, Precision and Robustness to assure the intended use of proposed method.

Specificity

The specificity of the developed analytical method is determined based on the absence of peaks due to additional components (excipients, impurities, degradants, etc) of placebo and blank (mobile phase) in their chromatograms. Specificity of the developed method is assessed by the ability to determine the analytes in the presence of components that are likely to be present such as excipients, impurities, matrix, degradants etc. Thus the chromatograms of mobile phase alone and that of placebo solution were checked for the presence of any peaks. The blank and placebo chromatograms were shown in Figure 2. Absence of peaks indicates the specificity of the method.

System Suitability

The intended use of the proposed analytical method was verified from the parameters of system suitability. The results were given in Table 1 for the system suitability and validation parameters where all the result values were found to be within acceptable limit.

Linearity

The results of the linearity given in Table 2 were plotted to check the linear relationship between concentration of analytes and the mean peak areas. The linearity plots were shown in Figure 3 and the correlation coefficient values were ≥ 0.999 for the four analytes.



**Divya Narla and Nagaraju Pappula****Precision**

Precision indicates the closeness of values for a series of measurements obtained under similar conditions. The results of precision were statistically expressed as percentage relative standard deviation(%RSD) and the set value for acceptance is not greater than 2.0. System precision or repeatability of the method was determined by injecting six replicates of working standard solution under the given set of conditions and the results were shown in Table 3. Method precision was assessed by injecting six replicates of working sample solution into the UPLC system and %RSD values were calculated statistically. The results were compiled in Table 4. Intermediate Precision or Interday precision was performed on two different days by using six standard solutions as represented in Table 5. The data was statistically analyzed and the % RSD values were calculated for each analyte. The % RSD values for the four analytes in precision study did not exceed 2.0demonstrating the high precision of the analytical method for quantitative analysis with consistency.

Accuracy

Accuracy of the present developed UPLC method was determined in terms of percentage recovery. The results of recovery studies carried out were given in Table 6 & 7. The closeness of measured value to the reference or standard value is indicative of method accuracy.

Forced degradation studies

Stress conditions with variable reagents were applied to the sample solutions to favor the degradation of analytes. The method is said to be stability indicating when the analyte peaks were not affected by the degradants. The degradation chromatograms under various stress conditions were shown in Figure 4 and the results of forced degradation studies were depicted in Table 8 & 9.

Assay

The analytical method was applied for the marketed formulation GENVOYA for quantification of four analytes. The assay values of Elvitegravir, Tenofovir alafenamide fumarate, Emtricitabine and Cobicistat were found to be 99.63, 100.82, 99.57 & 99.88 respectively. The UPLC chromatograms of standard and sample solution were shown in Figure 5.

DISCUSSION

The simultaneous quantification of selected drugs Elvitegravir, Tenofovir Alafenamide fumarate, Emtricitabine and Cobicistat was successfully achieved in the presence of their degradants by UPLC equipped with BEH C18 column, PDA detector, Mobile phase of Acetonitrile and 0.1% OPA in ratio of 55:45%v/v at 0.3ml/min flow rate. The results of validation of developed method gave satisfactory results.

CONCLUSION

Thereby it can be concluded that the proposed method can be utilized for estimation of four selected analytes in their fixed dose combination on a routine basis for quality control check with high specificity.

CONFLICT OF INTEREST

None.

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Table 1: Results of System Suitability and Validation

Parameter	Elvitegravir	Tenofovir alafenamide fumarate	Emtricitabine	Cobicistat
USP Plate count	4728.2	8812.4	14571.6	8801.6
USP tailing	1.04	0.848	0.56	1.02
Resolution	---	5.288	4.368	5.386
Retention time (Min)	0.401	1.039	1.467	2.129
Linearity range (µg/ml)	37.5-225	2.25-15	50-300	37.5-225
Correlation coefficient	0.9998	0.9991	0.9997	0.9996
Slope	15274.79	13051.5	20067.39	14025.42
Intercept	12663.68	2165.93	63349.1	35270.39
LOD (µg/ml)	0.45	0.03	0.6	0.45
LOQ (µg/ml)	1.5	0.10	2.0	1.5
Flow rate Minus(%RSD)	0.5	1.21	0.45	1.05
Flow rate plus (%RSD)	1.1	1.59	0.7	0.81
Mobile Phase Minus (%RSD)	0.76	0.92	0.36	0.32
Mobile phase Plus (%RSD)	1.08	1.37	0.47	1.0
Assay	99.21%	99.80%	99.80%	99.84%

%RSD-Percentage Relative Standard Deviation, LOD-Limit of Detection, LOQ-Limit of Quantification

Table 2: Linearity data

Elvitegravir		Tenofovir		Emtricitabine		Cobicistat	
Conc. (µg/mL)	Peak Area	Conc. (µg/mL)	Peak Area	Conc. (µg/mL)	Peak Area	Conc. (µg/mL)	Peak Area
0	0	0	0	0	0	0	0
37.50	565456	2.5	39337	50	1127459	37.50	572659
75	1174591	5	64104	100	2087563	75	1084453
112.5	1776362	7.5	100437	150	3054598	112.5	1645982
150	2301446	10	132224	200	4068982	150	2182698
187.5	2856479	12.5	168632	250	5137967	187.5	2644593





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225	3443210	15	195632	300	6030639	225	3161526
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Conc. – concentration

Table 3: System precision data

Injection No	Peak area response of drugs			
	Elvitegravir	Tenofovir Alafenamide Fumarate	Emtricitabine	Cobicistat
1	2339274	132319	4055679	2101286
2	2319553	133247	4072432	2120871
3	2344189	131054	4033387	2112783
4	2305510	130138	4027485	2106874
5	2344115	132055	4042066	2117136
6	2323067	131359	4061679	2121784
Mean	2329284.66	131695.33	4048788	2113455.66
STDEV	15750.96	1084.039	17371.79	8121.14
%RSD	0.6762	0.823	0.429	0.384

STDEV – Standard Deviation, %RSD – Percentage Relative Standard Deviation

Table 4: Method Precision Results

Inj. no.	Elvitegravir		Tenofovir Alafenamide Fumarate		Emtricitabine		Cobicistat	
	Peak area	Assay	Peak area	Assay	Peak area	Assay	Peak area	Assay
1	2339274	100.9	132319	100.3	4055679	100.2	2101286	99.3
2	2319553	100	133247	101	4072432	100.7	2120871	100.2
3	2344189	101.1	131054	99.3	4033387	99.7	2112783	99.8
4	2305510	99.4	130138	98.6	4027485	99.5	2106874	99.5
5	2344115	101.1	132055	100.1	4042066	99.9	2117136	100
6	2323067	100.2	131359	99.5	4061679	100.4	2121784	100.2
Mean	2329284.66	100.5	131695.33	99.8	4048788	100.1	2113455.66	99.8
STDEV	15750.96	0.695	1084.039	0.844	17371.79	0.45	8121.14	0.372
% RSD	0.6762	0.69	0.823	0.85	0.429	0.45	0.384	0.37

Inj – Injection, STDEV – Standard Deviation, %RSD – Percentage Relative Standard Deviation

Table 5: Results of Intermediate Precision

Inj. No	Peak area response of drugs							
	Elvitegravir		Tenofovir Alafenamide Fumarate		Emtricitabine		Cobicistat	
	Day - 1	Day - 2	Day - 1	Day - 2	Day - 1	Day - 2	Day - 1	Day - 2
1	2339274	2311234	132319	130430	4055679	4054786	2101286	2118125
2	2319553	2301328	133247	130320	4072432	4072367	2120871	2114871





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3	2344189	2341384	131054	133461	4033387	4041542	2112783	2127154
4	2305510	2323784	130138	132312	4027485	4035143	2106874	2116245
5	2344115	2333128	132055	132761	4042066	4046357	2117136	2110871
6	2323067	2313354	131359	133124	4061679	4082687	2121784	2127652
Mean	2329284.66	2320702	131695.33	132068	4048788	4055480.3	2113455.66	2119153
STDEV	15750.96	14903.9	1084.039	1366.302	17371.79	18530.85	8121.14	6821.866
% RSD	0.6762	0.64	0.823	1.0345	0.429	0.4569	0.384	0.32

Inj – Injection, STDEV – Standard Deviation, %RSD – Percentage Relative Standard Deviation

Table 6: Results of Recovery studies of Elvitegravir and Tenofovir Alafenamide Fumarate

% level	Elvitegravir				Tenofovir Alafenamide Fumarate			
	A.A	A.R	%R	Mean %R ± RSD	A.A	A.R	%R	Mean %R ± RSD
50	75	75.25	100.3	100.8 ± 0.45	5	4.97	99.4	99.3 ± 0.70
	75	75.9	101.2		5	5	100.0	
	75	75.69	100.9		5	4.93	98.6	
100	150.00	149.71	99.8	99.9 ± 0.36	10.00	9.91	99.1	99.86 ± 0.93
	150.00	149.33	99.6		10.00	9.96	99.6	
	150.00	150.38	100.3		10.00	10.09	100.9	
150	225	225.49	100.2	99.5 ± 0.58	15	15.09	100.6	100.2 ± 0.45
	225	222.9	99.1		15	15.05	100.3	
	225	223.34	99.3		15	14.95	99.7	

A.A:Amount Added, A.R: Amount Recovered, %R: Percentage Recovery, RSD:Relative Standard Deviation

Table 7: Results of Recovery studies of Emtricitabine and Cobicistat

% level	Emtricitabine				Cobicistat			
	A.A	A.R	%R	Mean %R ± RSD	A.A	A.R	%R	Mean %R ± RSD
50	100	99.73	99.7	100.0 ± 0.75	75	75.92	101.2	100.4 ± 0.68
	100	99.47	99.5		75	74.92	99.9	
	100	100.85	100.9		75	75.16	100.2	
100	200.00	200	100.0	99.9 ± 0.40	150	149.62	99.7	100.3 ± 0.55
	200.00	200.5	100.3		150	150.53	100.4	
	200.00	199.08	99.5		150	151.19	100.8	
150	300	299.18	99.7	99.96 ± 0.30	225	223.39	99.3	99.8 ± 0.68
	300	299.61	99.9		225	226.28	100.6	
	300	301.02	100.3		225	224.1	99.6	

A.A: Amount Added, A.R: Amount Recovered, %R: Percentage Recovery, RSD:Relative Standard Deviation

Table 8: Degradation Data for Elvitegravir & Tenofovir Alafenamide Fumarate

S.No	Degradation Conditions	Elvitegravir			Tenofovir Alafenamide Fumarate		
		Peak Area	% Assay	% Degradation	Peak Area	% Assay	% Degradation
1	Control	2312823	99.9	0.1	131618	99.9	0.1





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2	Acid	2193017	94.7	5.2	127512	96.8	3.1
3	Base	2235075	96.5	3.4	126849	96.3	3.6
4	Peroxide	2181507	94.2	5.7	125125	95	4.9
5	Thermal	2209854	95.4	4.5	125856	95.5	4.4
6	Photo	2189412	94.5	5.4	126478	96	3.9
7	Hydrolysis	2220156	95.9	4	128154	97.3	2.6

Table 9: Degradation Data for Emtricitabine & Cobicistat

S.No	Degradation Condition	Emtricitabine			Cobicistat		
		Peak Area	% Assay	% Degradation	Peak Area	% Assay	% Degradation
1	Control	4045147	100	0	2115254	99.9	0.1
2	Acid	3966415	98.1	1.9	2022463	95.5	4.4
3	Base	3951272	97.7	2.3	2042516	96.5	3.4
4	Peroxide	3891254	96.2	3.8	2012036	95	4.9
5	Thermal	3894512	96.3	3.7	2027589	95.8	4.1
6	Photo	3925163	97.1	2.9	2024712	95.6	4.3
7	Hydrolysis	4006241	99.1	0.9	2034781	96.1	3.8

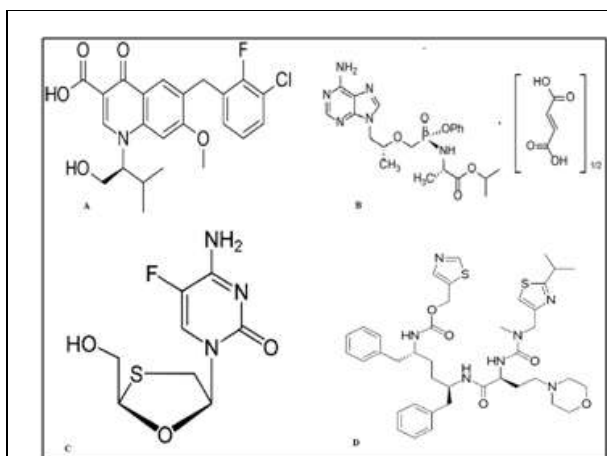


Figure 1: Chemical structures of Elvitegravir(A), Tenofovir Alafenamide Fumarate (B), Emtricitabine (C) and Cobicistat (D).

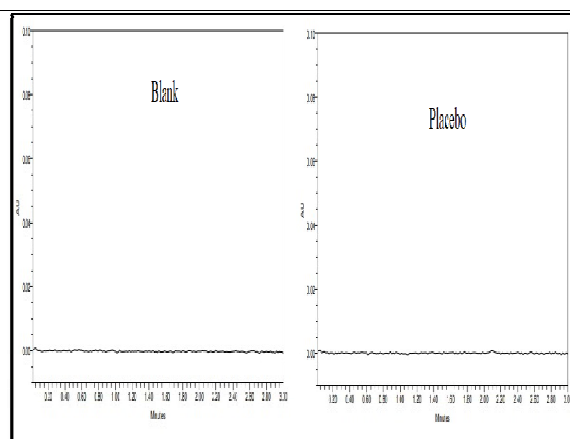


Figure 2: UPLC chromatogram of Blank and Placebo





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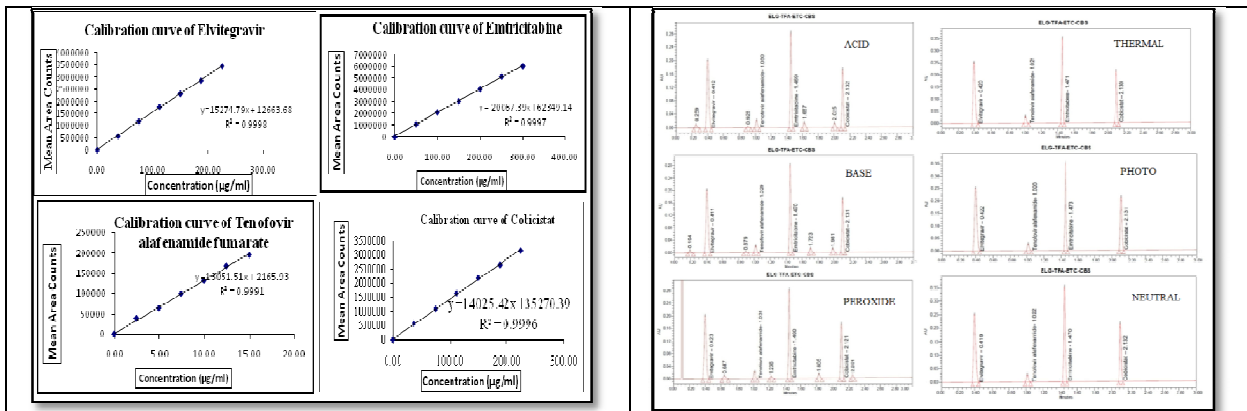


Figure 3: Calibration curves of ELV, TAF, EMT and CBS

Figure 4: UPLC chromatograms of Degradation studies

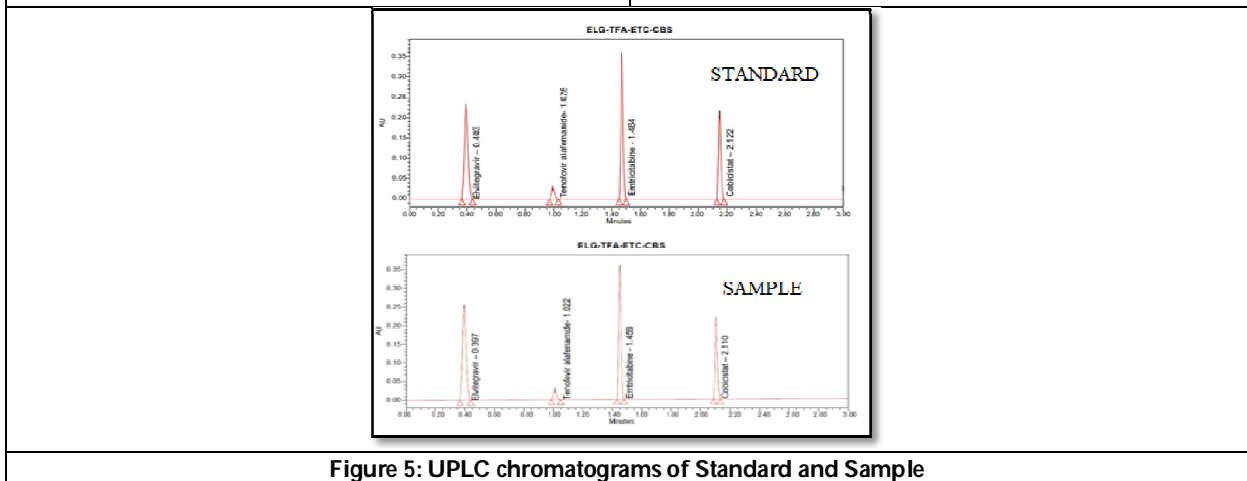


Figure 5: UPLC chromatograms of Standard and Sample





Technology-Enhanced Language Learning in English Education

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ABSTRACT

This study explores how technology-enhanced language learning (TELL) is developing in the field of English teaching. It offers a thorough summary of the most recent developments, obstacles, and possibilities influencing the use of technology in English language training. Drawing upon a synthesis of recent research, the paper identifies prominent trends such as the widespread use of mobile applications, online platforms, and digital resources for language learning. Additionally, it examines innovative pedagogical approaches, including computer-assisted language learning (CALL), blended learning models, and gamification strategies, which have gained traction in enhancing language acquisition and engagement among learners. Despite the promising developments, the paper also addresses several challenges hindering the effective implementation of TELL in English education. These challenges encompass issues related to digital divide, access to technology, teacher training, and concerns regarding the quality and appropriateness of digital resources. Furthermore, the paper highlights the importance of addressing socio-cultural and linguistic diversity to ensure inclusivity and equity in technology-mediated language learning environments. Amidst the challenges, the paper underscores the vast opportunities offered by technology in English language education. These opportunities include personalized learning experiences, authentic language practice through immersive simulations, and the facilitation of global collaboration and communication. By seizing these chances and tackling the related obstacles, teachers may fully utilize technology to create engaging and productive English language learning environments for a variety of students.

Keywords: TELL: Technology-enhanced language learning, English Education, technology, training, etc.



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INTRODUCTION

The core purpose of learning English is to interact with others. This aligns perfectly with effective teaching methods, which also emphasize communication. It's uncommon to find a language class devoid of technology, as it's a valuable tool for developing students' real-world communication skills in the new language. Traditionally, Indian high school English classes rely on large groups, teacher-centered grammar-translation methods, and exam-oriented textbook lectures. This decontextualized approach makes it challenging for students to apply their knowledge flexibly in everyday situations. Large class sizes further restrict individual participation and one-on-one communication with teachers or peers. Fortunately, technology has emerged as a powerful tool to both support and enrich language learning. Educators are increasingly incorporating various technologies to enhance their teaching, engage students, provide authentic cultural examples, and establish a connection between their courses. Teachers can also tailor activities and differentiate instruction using technology, meeting the requirements of each student and fostering a more engaging learning environment. Even though technology is becoming more and more important in language learning, the efficiency of this tool ultimately depends on the skills and knowledge of the teachers who oversee and support the classroom.

LITERATURE REVIEW

Technology-enhanced language learning (TELL) has emerged as a dynamic field within English education, offering both opportunities and challenges for language learners and educators alike. This section reviews key literature on trends, challenges, and opportunities in TELL within the context of English education.

Trends in TELL

Numerous trends influencing TELL in English instruction are highlighted by recent studies. The growing use of digital materials, internet platforms, and mobile applications into language training is one notable development (Hubbard, 2018). This pattern illustrates how technology is being used more and more to support language learning outside of traditional classroom environments. Furthermore, studies highlight the significance of implementing cutting-edge pedagogical techniques to improve learner engagement and motivation, such as gamification techniques and computer-assisted language learning (CALL) (Chapelle, 2020). These developments highlight how TELL is changing and how it has the power to revolutionize English language instruction.

Challenges in TELL

TELL has many obstacles that prevent it from being used effectively in English instruction, despite its potential. One significant problem is the "digital divide," which refers to variations in students' access to technology and internet connectivity (Warschauer, 2019). Inequalities in language learning possibilities are made worse by this difference, especially for students from underprivileged families. Concerns over the caliber and applicability of digital resources used in TELL have also been voiced, underscoring the necessity of carefully assessing and choosing technological tools (Kessler, 2016). Additionally, studies indicate that insufficient teacher preparation and assistance in incorporating technology into language learning impede the successful execution of TELL (Levy & Stockwell, 2021). In order to provide fair access to TELL resources and optimize their influence on English language learning objectives, these obstacles must be overcome.

Opportunities in TELL

TELL offers many options to improve English instruction in spite of obstacles. Personalized learning experiences made possible by technological tools present a significant opportunity since they let students customize their language learning path to suit their unique requirements and preferences (Godwin-Jones, 2018). Additionally, TELL facilitates meaningful interactions in real-world scenarios by providing immersive simulations and digital communication platforms for realistic language practice (Meskill & Anthony, 2017). Technology also makes cross-cultural cooperation and exchange easier, exposing students to a variety of viewpoints and improving their



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intercultural competency (Thorne, 2020). These chances highlight how TELL can significantly improve English language learners' ability to communicate across cultural boundaries and acquire an effective language.

The literature review emphasizes how TELL is dynamic in English teaching, highlighting its changing patterns, enduring difficulties, and exciting prospects. Teachers may fully utilize TELL to improve English language learning outcomes and advance inclusive and equitable education for all students by tackling obstacles and seizing opportunities.

TECHNOLOGY-ENHANCED LANGUAGE LEARNING (TELL)

Technology-Enhanced Language Learning (TELL) - often called computer-mediated language learning - investigates how technology affects learning a second language. Through the use of computers as a technology instrument, TELL presents multimedia information in addition to the teaching strategies used by language teachers. It's critical to understand that TELL serves as an adjunctive strategy to support current teaching approaches rather than as a stand-alone teaching style. TELL is closely related to Computer-Mediated Communication (CMC), a field that has been well researched and approved for its effectiveness in supporting students' oral and written foreign language skills. This combination helps students who struggle with language to express themselves both orally and in writing by filling in the gaps in their verbal communication of concepts in the target language. Technology-enhanced language learning makes use of computer hardware, software, and internet resources to improve language learning and instruction. This method covers a range of activities designed to improve language learning, including using portable electronic dictionaries in class, conversing with classmates in English over Instant Messenger, reading news websites, taking part in online discussion boards, finishing computer-based language exercises from the CDs that accompany textbooks, searching words in corpora for contextual usage exploration, immersing oneself in the language through games like World of Warcraft, and texting classmates in English. The concept of TELL is derived from a variety of factors, such as the types of activities (such as fill-in-the-blank, video creation, and chatting), the language skills (reading, writing, speaking, listening, and grammar) that are targeted, the instructional settings (such as blended, distance, and online), and the technological tools that are used (computer, Internet, chat, blog, wiki, gaming, video).

Contemplations on General Learning Resources

When contemplating general learning resources, various factors warrant careful consideration. Decision-makers, including department heads, school board members, and educators, must meticulously assess the content, format, instructional methodologies, evaluation mechanisms, assessment criteria, and treatment of societal issues inherent within these resources. Equally vital are the diverse needs of the intended audience, encompassing considerations such as age, linguistic background, and special educational requirements. Additionally, the purpose, distinctive characteristics, and effective utilization of the available media selections should be thoroughly evaluated. It is imperative to prioritize the strengths of resources over perceived weaknesses, ensuring alignment with educational goals and the diverse learning needs of students.

Content/Format/Design: Considerations for Learning Resources**Content**

- Ensure accuracy, relevance, and alignment with curriculum objectives.
- Incorporate up-to-date information and authentic materials to enhance learning outcomes.
- Provide a diverse range of content to cater to varying learning styles and preferences.
- Include clear learning objectives and instructional goals to guide learners effectively.

Format

- Optimize readability by using clear fonts, appropriate font sizes, and spacing.
- Organize content in a logical and coherent manner to facilitate comprehension.
- To increase engagement, use multimedia components like pictures, movies, and interactive elements.
- Ensure compatibility with different devices and platforms to promote accessibility for all learners.



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- Create visually appealing layouts that attract and maintain learners' attention.
- Implement user-friendly navigation features to facilitate ease of use.
- Incorporate instructional scaffolding elements such as prompts, cues, and feedback to support learning progression.
- Maintain consistency in design elements throughout the learning resources to enhance coherence and usability.

METHODOLOGY**Educational materials should**

- ✓ prioritize experiential learning over passive instruction
- ✓ facilitate collaborative and independent learning to accommodate individual development
- ✓ advocate for practical, hands-on learning experiences.
- ✓ cultivate critical-thinking and decision-making skills through questioning, reflection, and analysis.
- ✓ provide options and adaptability to address individual differences in aptitude, ability, learning preferences, multiple intelligences, and interests.

Appraisal/ Appraisement: Educational materials ought to

1. encourages ongoing learning by the learner
2. allow for both developmental and conclusive appraisal/evaluation as suitable
3. cater to the requirements of the learner

Advantages of Technology-Enhanced Language Learning (TELL)

1. **Enhanced Engagement:** TELL provides learners with engaging, multimedia-rich learning experiences that pique their interest and inspire them to participate more.
2. **Access to Real-World Language and Cultural Contexts:** TELL provides students with real-world language exposure by giving them access to real-world language resources including podcasts, articles, and videos.
3. **Personalized Learning:** To better meet the needs of each learner, TELL systems frequently offer adaptive learning capabilities that enable customized content selection, pacing, and feedback. These elements increase the efficacy of learning.
4. **Flexibility and Convenience:** Self-paced learning, asynchronous communication, and remote collaboration are made possible by TELL, which gives students access to language learning resources at any time and from any location.
5. **Enhanced Language Skills:** TELL facilitates the development of all language skills—speaking, listening, reading, and writing—through interactive activities, multimedia content, and communication tools, leading to holistic language proficiency.
6. **Cultural Awareness:** By exposing students to a range of cultural viewpoints and real-world language usage, TELL promotes intercultural competency and sensitivity.
7. **Opportunities for Collaborative Learning:** TELL platforms frequently include social aspects like discussion boards, group projects, and peer evaluation, which encourage meaningful engagement and cooperation among students.
8. **Instant Feedback:** TELL technologies frequently offer learners immediate feedback on language exercises and exams, enabling them to track their development, pinpoint areas for growth, and promptly modify their learning approaches.
9. **Cost-effectiveness:** TELL might possibly save institutions' and students' overall language learning expenses by eliminating the requirement for traditional classroom materials like textbooks and workbooks.



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10. The TELL program prepares students for success in today's digital workplace by providing them with the digital literacy skills and knowledge necessary to navigate the increasingly linked and digitally advanced world.

Disadvantages of Technology-Enhanced Language Learning (TELL)

1. **Technological Problems:** TELL systems may experience internet connectivity challenges, device compatibility problems, or technological hiccups that impede learning and aggravate teachers and students.
2. **Digital Divide:** Because TELL depends on having access to the internet and technology, it may widen already-existing gaps in students' access to resources and education, especially for those from low-income families or those who live in rural locations with inadequate infrastructure.
3. **Possibility for Distraction:** When technology is used for language learning, learners may become distracted by non-educational websites, social media, or games, which takes their focus away from language learning goals and tasks.
4. **Lack of Human Interaction:** The use of technology in education may limit possibilities for in-person meetings and interpersonal connection, which might hinder students' capacity to hone their speaking and listening abilities in authentic settings and build sociocultural competency.
5. **Over-reliance on Technology:** Teachers' creativity and adaptability in the classroom, as well as students' capacity to interact with a variety of learning materials and adapt to various learning environments, may be compromised by an over-reliance on TELL tools and resources.
6. **Content Quality:** Some TELL materials may not be of the highest caliber or pedagogically sound, which might result in poor learning outcomes, misunderstandings, or the reinforcement of grammatical faults.
7. **Limited Feedback and engagement:** Learners' opportunities for meaningful engagement, individualized coaching, and formative evaluation may be limited by automated feedback systems in TELL technologies, which may lack the depth and nuance of feedback given by human instructors.
8. **Cultural Insensitivity:** TELL materials may not adequately reflect learners' cultural backgrounds, values, or linguistic varieties, potentially perpetuating cultural stereotypes or excluding marginalized groups from the learning process.
9. **Pedagogical Challenges:** Integrating technology into language teaching requires training, professional development, and ongoing support for educators to effectively leverage TELL tools and methodologies, which may pose pedagogical challenges and barriers to implementation.
10. **Cultural Insensitivity:** TELL materials might not fairly represent the cultural backgrounds, values, or linguistic diversity of students, which could reinforce cultural stereotypes or discourage underrepresented groups from participating in the educational process.
11. **Pedagogical obstacles:** To effectively use TELL technologies and approaches, educators must get training, professional development, and continuing support. This can provide pedagogical obstacles as well as implementation barriers.

Main Types of Media Used in Technology-Enhanced Language Learning (TELL)

1. **Interactive Multimedia:** Interactive multimedia tools use a range of media elements, such as text, graphics, audio, video, and animations, to provide students with dynamic, immersive language learning experiences. Multimedia language classes, online interactive exercises, and interactive language learning apps are a few examples.
2. **Digital Texts and E-books:** These resources give students access to a variety of digital reading materials in the language of instruction, such as online articles, e-textbooks, and e-readers. Frequently, these tools provide functionalities like multimedia improvements, notes, and dictionary look-up to aid in language acquisition and understanding.
3. **Audiovisual materials:** Videos, podcasts, and audio recordings are examples of audiovisual materials that provide learners with real-world language exposure, exposing them to pronunciation, intonation, natural language use, and cultural nuances. Activities including speaking practice, listening comprehension, and cultural knowledge can all benefit from these tools.



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4. **Online Communication Tools:** With online communication tools like email, chat rooms, discussion forums, and video conferencing platforms, students may work together and communicate in real time with classmates, teachers, and native speakers of the language they are studying. These tools facilitate language practice, interaction, and cross-cultural communication in authentic communicative environments.
5. **Virtual Reality (VR) and Augmented Reality (AR):** These technologies put students in simulated settings where they can communicate with virtual characters, scenarios, and objects in the language of instruction. Applications for VR and AR provide chances for language use in context-rich environments, cultural inquiry, and experiential learning.
6. **Gamified Learning Platforms:** To encourage students and improve participation in language learning activities, gamified learning platforms make use of game-based components like challenges, rewards, and progress tracking. In order to reinforce language skills and concepts, these platforms frequently include role-playing games, quizzes, simulations, and language learning games.
7. **Social Media Platforms and Social Networking Sites:** Through online discussions, teamwork, and peer evaluation, language learners can connect with peers, exchange language-related resources, take part in language learning communities, and practice their language skills.
8. **Online Language Learning Platforms:** Via web-based interfaces, online language learning platforms provide thorough language courses, tutorials, exercises, and evaluations. To facilitate customized language learning routes, these systems frequently include adaptive learning algorithms, personalized feedback, and progress tracking tools.

CONCLUSION

The investigation of technology-enhanced language learning (TELL) in the context of teaching English reveals a changing environment with potential that are bright and obstacles that never go away. The incorporation of technology in language education has resulted in inventive teaching methods, improved involvement of learners, and refined language acquisition encounters. But issues like the digital divide, worries about the caliber of digital resources, and the requirement for support and training for teachers continue to be major obstacles to the successful implementation of TELL. Even with these difficulties, there are several of ways that TELL may support individualized education, develop intercultural competency, and get students ready for the digital age. Teachers may fully utilize TELL to improve English language learning outcomes and advance inclusive and equitable education for all students by tackling obstacles and seizing opportunities. To ensure that technology continues to be an effective tool for improving English education and enabling students to succeed in a worldwide society, stakeholders must work together, be creative, and adjust to the evolving TELL landscape.

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DIKSHA as a Catalyst for Technology Integration in Indian Classrooms

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ABSTRACT

DIKSHA, the Digital Infrastructure for Knowledge Sharing, has emerged as a transformative force in Indian education, catalyzing the integration of technology in classrooms. Launched by the Government of India, DIKSHA aims to enhance the quality and accessibility of education across diverse settings. This abstract provides a concise overview of DIKSHA's impact on technology integration in Indian classrooms. DIKSHA plays a pivotal role in digitizing educational content, offering a comprehensive repository of textbooks, videos, simulations, and assessments aligned with national curriculum standards. It empowers teachers through professional development modules and collaborative platforms, fostering innovative pedagogical practices. The platform's emphasis on inclusivity is evident in its provision of content in multiple languages, addressing India's linguistic diversity. The impact of DIKSHA extends to the transformation of classroom dynamics, enabling teachers to adopt interactive and engaging teaching methods. Students benefit from personalized and self-paced learning experiences, cultivating a deeper understanding of subjects. However, challenges such as infrastructural disparities and digital literacy gaps persist, necessitating ongoing efforts to ensure effective implementation. DIKSHA stands as a catalyst for technology integration in Indian classrooms, revolutionizing teaching and learning practices. As the platform evolves, addressing challenges will be crucial to sustaining its positive impact on the nation's education landscape.

Keywords: DIKSHA, Digital Learning, ICT, Knowledge, etc.





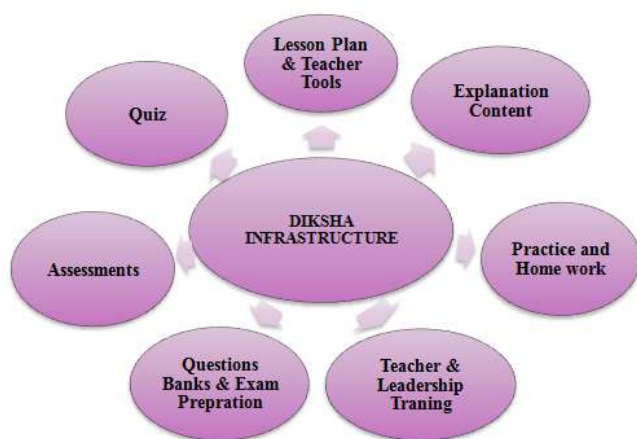
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INTRODUCTION

All pupils could benefit greatly from high-quality learning experiences thanks to ICT integration in the classroom. A wide range of technologically advanced tools and platforms are available to educators in India to help them work together, maximize resource sharing, and create dynamic learning environments. Students can now acquire knowledge and skills despite socioeconomic and geographic constraints because to the government's "Digital India" push and the widespread use of the internet. As a single digital platform for instructors, the Ministry of Human Resources and Development's DIKSHA program is a noteworthy contributor to this ecosystem of digital education. Through the use of scalable digital infrastructures, DIKSHA gives educators the ability to produce content, obtain resources, and interact with a larger learning community. Especially noteworthy is DIKSHA's contribution amid the interruptions caused by the COVID-19 epidemic, enabling remote learning through creative state programs and accelerating the adoption of technology in education. This platform continuously expands its content through digital methods and offers flexible, tailored learning at the learner's pace. This guide provides a thorough implementation of DIKSHA in schools by providing information on curriculum development, teacher preparation, infrastructure readiness, and leadership. It gives administrators the means to establish a nurturing atmosphere that guarantees educators and learners can make the most of DIKSHA's resources. These recommendations facilitate a collaborative effort towards an improved digital learning experience and are of great value to a wide range of stakeholders, including teachers, parents, students, school administrators, and teacher educators.

DIKSHA Platform

The Digital Knowledge Sharing Infrastructure, or DIKSHA, is a national platform that was started in 2017 by the Ministry of Education's National Council for Education Research and Training (NCERT). It acts as a central location for a wide range of curriculum-linked e-content that is designed to satisfy the requirements of teachers and students in every state and union territory. DIKSHA is available on multiple digital platforms, including laptops, smartphones, desktops, and tablets. It utilizes QR-coded Energized Textbooks to facilitate easy engagement. Its many features, which include news updates, instructor profiles, assessment tools, in-class resources, teacher training materials, and communication channels, all work together to create a dynamic teacher community. With support for more than thirty languages, DIKSHA conforms to the national curriculum standards for grades 1 through 12 as set forth by NCERT, CBSE, and SCERT. Additionally, the platform gives every state and UT the freedom to design programs specifically for their teachers and students, allowing them to personalize the DIKSHA experience to meet their specific requirements. The primary objective of DIKSHA is to function as a clearinghouse for Open Educational Resources (OERs), meeting the needs of the ever-changing educational environment and benefiting teachers and students in equal measure.



**Lohans Kumar Kalyani****DIKSHA's (National Teachers Platform) significance**

The National Teachers Platform, or DIKSHA, is significant because of its core design philosophy, which places teachers first in both use and development. In the field of teacher education, DIKSHA becomes a facilitator, accelerator, and amplifier of creative ideas as a result. Its versatility allows states, governmental agencies, and commercial organizations to effortlessly integrate DIKSHA into their own teacher-centric programs, adjusting its use according to their distinct aims, requirements, and capacities. Moreover, DIKSHA broadens its scope to meet the educational demands of students rather than concentrating just on the pedagogical components for educators. By giving children nationwide access to NCERT texts and curricula that are in line with the regular school curriculum, DIKSHA guarantees that their education is both uniform and enriching. This inclusive approach underlines DIKSHA's role in establishing a collaborative educational ecosystem, where many stakeholders can actively participate, contribute, and harness the potential of a unified platform to reach educational objectives on a national scale.

DIKSHA e-learning Portal Advantages

The DIKSHA e-learning platform has numerous benefits to offer. Touted as the National Digital Infrastructure for Teachers, DIKSHA serves as a complete instrument that equips educators around the country with state-of-the-art digital technology, covering every stage of the teacher's career. When it comes to student involvement, DIKSHA makes it easier for instructors and students to communicate directly, which promotes a more complex and interactive grasp of different concepts. In addition to improving learning, this interactive method gives students a chance to ask questions of their teachers one-on-one and get their questions answered. In addition to providing parents with access to personalized sessions with teachers after regular school hours, the portal also helps parents stay informed about what their children are doing in class. The diverse advantages of DIKSHA highlight its essential role in transforming the educational system and guaranteeing the engagement and holistic growth of educators, learners, and parents.

What The Platform Offers?

The NTP Offers are:

- Extensive courses for teacher training that address a variety of topics, including learning objectives, Continuous and Comprehensive Evaluation (CCE), and more.
- A wealth of instructional materials, such as carefully thought-out lesson plans, thought-provoking films, and deftly created worksheets, all in line with the recommended curriculum.
- Tailored exams for teachers, providing insights into their strengths and areas that demand improvement.

Teachers may access this educational content offline with ease thanks to our user-friendly site, using their cellphones, tablets, or other devices whenever it's convenient for them, no matter where they are. Moreover, the content is carefully matched to the curriculum and tailored to the needs of local languages, guaranteeing its applicability and efficacy in a variety of educational settings.

Objective

The platform's objective is to act as a storehouse for Open Educational Resources (OERs), giving teachers and students a place to collaborate. The aim is to establish the platform as a collaborative area for a wide spectrum of education stakeholders, such as academics, experts, governmental agencies, independent schools, non-governmental organizations, and commercial enterprises. These organizations are urged to actively participate, make contributions, and utilize the platform's combined capabilities in order to achieve the country's broad learning goals. The Indian government emphasizes its function as a comprehensive and inclusive hub of educational resources, and sees it as a uniting "One Nation One Platform" for school education.

Features

- The portal includes curriculum-aligned worksheets, concept videos, and lesson plans, among other educational resources. In order to foster a cooperative teacher community, it also has news updates, instructor profiles, assessment tools, teacher training materials, and communication features.



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- The materials can be accessed through online and offline platforms, supporting smartphones, tablets, and other devices. They are customized to meet curricular requirements and are available in local languages.
- It provides users with access to an extensive range of curriculum-linked electronic content via many platforms, such as QR-coded Energized Textbooks (ETBs).
- Progress Monitoring Chart.
- The platform's user interactions provide extensive, anonymized data that helps administrators, teachers in the state of Utah, and content developers successfully plan programs and interventions.

Expected Outcomes

- Offering educators personalized and customized professional development opportunities at any time and place.
- Encouraging teachers to share resources effectively, maximizing their time and efforts.
- Provision of a tailored workplace for teachers, supporting in planning and monitoring their progress.
- Establishment of a complete platform, facilitating seamless contact among all parties.
- Standardized observation tools are being implemented on the platform, providing data to stakeholders to support ongoing training, teacher assistance, and analytical projects.

How will Teachers benefit?

DIKSHA, the National Digital Infrastructure created specifically for educators and easily accessible via a mobile application, has a lot to offer teachers. With so many lesson ideas, worksheets, and interesting exercises, it makes for a fun learning environment in the classroom. Teachers have a rare opportunity to fully comprehend their professional trajectory with the help of this portal. Teachers can map their career progression and skill improvement from their first days of school till retirement. Thus, this cutting-edge platform equips educators with resources for both short-term classroom impact and long-term career planning.

Advantages for Teachers

- Find engaging and interactive learning materials to improve student participation in the classroom.
- Examine and discuss with other teachers the most efficient ways to explain difficult subjects.
- Enroll in classes to further your career development, and when you finish, you can receive certifications and badges.
- Examine the lessons you have learned over your time working as a school teacher.
- Follow the State Department's official announcements to stay informed.
- Use digital tests to see how well your pupils understand the material that has been taught.

How will Students benefit?

Access to the DIKSHA app equips students with the ability to grasp concepts effortlessly and interactively. The app incorporates features that enable comprehensive lesson revisions, ensuring a thorough understanding. Furthermore, students can evaluate their learning independently through self-assessment practice exercises, enhancing their overall comprehension and mastery of the taught material.

How will Parents benefit?

Parents, with the DIKSHA app on their mobile devices, gain the ability to monitor classroom activities and address queries outside regular school hours. This platform serves as a comprehensive tool for seamless interaction among all stakeholders, ensuring a hassle-free experience for parents to stay informed and engage with their child's educational journey.

Benefits for Students and Parents.

- Easily access associated lessons on the platform by scanning QR codes in your textbook.
- Review and reinforce classroom-learned lessons.
- Explore supplementary materials on challenging topics for better understanding.
- Engage in problem-solving practice with instant feedback on the correctness of the answers.



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Top of Form

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- **Usefulness of Diksha Portal in the current education system**

The Diksha Portal stands as a cornerstone in the contemporary education system, offering multifaceted utility that significantly transforms the teaching and learning landscape. One of its primary strengths lies in serving as a centralized hub for educational resources, providing teachers with a wealth of digital tools and content to enhance their pedagogical practices. From comprehensive training modules on various educational methodologies to an extensive repository of teaching resources such as lesson plans, concept videos, and worksheets, the Diksha Portal empowers educators with a dynamic toolkit. Moreover, the platform plays a pivotal role in assessing teachers' proficiency, offering personalized insights into their strengths and areas for improvement. This feature contributes to ongoing professional development, fostering a culture of continuous improvement among educators. The Diksha Portal's user-friendly interface ensures accessibility for teachers, allowing them to engage with educational material offline on their smartphones, tablets, or other devices, promoting flexibility in learning. In the context of the broader education system, the Diksha Portal facilitates direct interaction between teachers and students, fostering a more interactive and engaging learning experience. It supports a blended learning approach, enabling students to access digital resources aligned with the curriculum, promoting a deeper understanding of concepts. Furthermore, the Diksha Portal enhances parental involvement by providing a window into classroom activities and opportunities for one-on-one sessions with teachers. This aspect bridges the communication gap between educators and parents, creating a collaborative educational environment. The Diksha Portal's usefulness in the current education system extends far beyond being a repository of digital resources. It serves as a catalyst for innovation, professional growth, and improved learning outcomes, contributing significantly to the evolution of a dynamic and responsive educational ecosystem.

CONCLUSION

The research sheds light on the transformative role of DIKSHA as a catalyst for technology integration in Indian classrooms. The platform stands as a pioneering force, driving a paradigm shift in the traditional educational landscape by seamlessly blending technology with pedagogy. Through its comprehensive offerings, ranging from teacher training modules to a rich repository of teaching resources, DIKSHA emerges as a dynamic tool empowering educators across the nation. DIKSHA's significance is not only confined to enriching the professional lives of teachers but extends to fostering interactive and engaging learning experiences for students. The platform's ability to facilitate direct teacher-student interaction, coupled with access to digital resources aligned with the curriculum, positions it at the forefront of the digital revolution in Indian education. The research underscores the crucial role of DIKSHA in addressing the diverse needs of the education system. Its adaptability to offline access ensures that teachers can seamlessly engage with educational material, overcoming infrastructural challenges. Moreover, the platform's emphasis on assessments for teachers contributes to their continuous professional development, creating a culture of ongoing improvement. Beyond the classroom, DIKSHA promotes parental involvement by providing insights into classroom activities and avenues for personalized interactions with teachers. This not only bridges the gap between educators and parents but also fosters a collaborative approach to a child's education. As technology continues to evolve, DIKSHA stands as a beacon, guiding the education sector toward a more inclusive, flexible, and innovative future. Its success as a catalyst for technology integration reflects a collective commitment to leveraging digital tools to enhance the quality of education in India. The research underscores the need for sustained efforts in harnessing technology to address educational challenges, with DIKSHA serving as an inspiring model for effective technology integration in Indian classrooms. Ultimately, DIKSHA emerges not merely as a platform but as a transformative force propelling Indian education into a digitally empowered era.





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Exploring the Interdisciplinary Nature of Natural Sciences in Architecture Education and Profession

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ABSTRACT

Architecture is a highly interdisciplinary field that draws inspiration from a wide range of natural and social sciences. Architecture and natural science have a significant influence on the construction of structures and the surrounding environment. Natural science is a branch of study that combines the understanding of the physical world through applicable elements of physics, chemistry, biology, earth science, or astronomy, among other disciplines, according to Guo (2021). Architecture is a subject that includes a multitudinous sphere as its foundation and is associated with the processes of planning and designing as well as the construction of human-made structures. Now, there is a requirement to have a wide understanding of numerous factors, such as ornamental and utilitarian functions and disassemblability. The modern architectural profession is at the crossroads due to innumerable impacts that have been introduced to the profession by the natural and social sciences. The application of scientific perspective in architecture education and profession means that the aim is to promote the proper growth of a structure that is strong, durable, and good-looking. It allows architects to create more profound and satisfying shapes, as well as worth and lasting space. This research paper aims to look at the cross-cutting nature of natural sciences in architecture education and practice with special reference to the construction and design of sustainable, energy-efficient, safe, and stable structures

Keywords: -Architecture, Natural Science, Sustainability, Energy Efficiency, Safety, Stability



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INTRODUCTION

The study of natural sciences entails observing, experimenting, and using theories to investigate nature. The laws that govern the universe and the Earth, where various disciplines are to be identified as counterparts or reflections. Natural science includes the following disciplines: These are the following disciplines of knowledge: physics, chemistry, biology, earth science, and astronomy. These fields are related to major components of architecture, as illustrated in figure 1 below. The potential and decision-making of the natural science, which architects need to comprehend, concerns its working. The procedure used in architectural design commences with site planning, in which earth science is taken into account. The type of land, its fertility, terrain and grading, climatic conditions, and the sky are all important considerations. After analyzing all these terms, design is arrived at, or defined, in other words. For such purposes as laying the foundation and beginning to construct, the characteristics of the land's geology are crucial.

Also, the design process entails planning of particular spaces that should have natural lighting and airflow as per the need and use of the space. To implement well-thought-out decisions, the direction of the sun, changes in seasons, and wind have to be researched. Further in the process of building, physics also plays a vital role in the determination of the structural integrity as well as the materials to be applied in the building process. This can be regarded as a concept that has sustainability at its core: biophilic design, which can be defined as designing with nature. As a result, biophilia helps to keep not only the indoor but also the external environment comfortable and effective.

PHYSICS

Physics can be defined as a branch of natural science that encompasses the qualities of matter and energy. Concepts of and behaviour under these circumstances are refereed. Thus, the building physics can be considered as having a significant impact on the design phase. Building Physics as a part of architecture focuses on the heat and moisture behaviour of the construction materials and structural components, indoor and material moisture, noise and hearing comfort, thermal and daylighting design, mechanical ventilation, energy aspects, and structures. However, practical complications are the principal issues that arise with the contemporary development of architecture in terms of spectacular structures with large cantilevers, various shapes, heights, and new parametric constructions. The concepts of such forms of creativity entail well-measured structuring of physics in such structures. Architecture and design of the columns, beams, and walls of the building are done with the help of principles of physics by structural engineers. There are concerns about providing weight bearing and support for inward and outward forces such as wind pressure, earthquakes, and snow load.

CHEMISTRY

Chemistry is a branch of sciences that deals with the nature, structure, and behaviour of substances, and being one of the fundamental sciences, it plays a major role in the advancement of architectural design because it influences the creation of construction materials and technology. It can thus be argued that the field of chemistry takes on a rather central function in determining the strength, durability, and sustainability of the structures being built. To ensure that correct materials are used in the construction of a given structure, architects are obliged to put into consideration information from chemistry, including location and climate of the area the building is to be constructed in, strength of the given material, ability of the material to combat corrosion, and durability. They also need to know what chemically is going on in the building to ensure that the structure of the building stays intact.

1. For example, concrete, which is the most commonly used building material all over the world, is created through a mixture of aggregates, water, and cement. Some of the technical factors, including setting time, strength of the cement, and workability, are some of the important chemical properties of cement related to the quality of the final product. In addition, the chemical composition of the particles in concrete has an effect on every aspect of the material, including its strength, durability, look, and texture.



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2. Steel, a commonly used construction material, is made up of iron, carbon, and several alloying elements. The strength, ductility, and corrosion resistance of steel are determined by its chemical composition, resulting in a material that is both structurally versatile and durable.
3. Contemporary building significantly depends on glass, which is produced by subjecting silica and other components to extreme heat. A glass's chemical composition influences its thermal properties, strength, color, and transparency. Because its composition may be changed, several forms of glass with varying attributes have been developed.
4. Chemicals are utilized in almost every aspect of building construction and maintenance, including adhesive, waterproofing chemical and sealants used to keep basements dry and roof membranes that reflect light and keep roofs cool.
5. The building and design industry has been able to develop a diverse array of high-performance materials and products that can assist in the resolution of a variety of issues, including the mitigation of the effects of climate change, the enhancement of the health and wellness of building occupants, the enhancement of energy efficiency, and the resistance of buildings to natural disasters, as a result of advancements in chemistry and materials science.

In conclusion, the quality and sustainability of structures are significantly influenced by the chemical properties of building materials, rendering chemistry a critical element of architecture. The future of the field can be influenced by the collaborative development of new and improved construction materials and technologies through continuous research and innovation.

BIOLOGY

Biology is increasingly impacting design processes as a scientific discipline. This has led to a shift in design methodologies towards a novel hybrid framework in which architects have made an effort to mimic nature by grasping every opportunity to create more effective solutions. In recent years, there has been significant progress in the use of bio-mimicry, mostly because to the rapid development of technology. Architecture has an influence taken from the works of nature, and these architects have come up with buildings that resemble the existing surroundings. To rehearse non-summarised inspiration in the outline, one can notice the use of natural forms and materials, as well as the spaces that are part of the landscape.

1. Biomimetic is defined as the use of biological principles and structures inherent in living organisms for the purpose of designing, adapting, or deriving new technologies or products, according to the present study.
2. It is not the first time that architecture takes ideas from biology, and one can remember the ancient Greeks and Romans that used the motives of the leaves in the friezes of their constructions, the Art Nouveau, and Frank Lloyd Wright, who wanted to create a transformation between his constructions and nature.
3. Biology is applied by architects in the construction of structures that are considered efficient in terms of energy and features that are sustainable in the environment. They apply knowledge of the relationship between organisms and their surroundings in order to ensure that the building does not have a terrible effect of the physical environment it is built in.
4. They are found in ourselves, in other living organisms, in the natural formation, and basically in art worldwide; even in the proportions of the universe, big and small, the measures are in the golden rectangle. For the ancient philosophers, it was extremely significant in spite of the fact that their perception of proportions was quite different and limited; according to them, they were divine, and moreover, they simply look good. However, one must acknowledge the fact that architects incorporated the principles of the golden ratio in designing structures way before the discovery. You can see the impact of this isolated ratio in ancient temples, medieval cathedrals, and early 20th-century buildings.
5. Thus, the confrontation of biological and technological aspects into the architecture settles an actually unexampled idea and a mentality in architecture. Biodesign, or biofabrication, is a branch that uses biological processes to provide architectural solutions that are much more sustainable, adaptable, and innovative.



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6. In regard to the sub-discipline of biology, ecological studies are a sub-discipline that carries immense importance in the field of architecture in contemporary society. Said to be defined by the Oxford English Dictionary as 'the branch of biology,' this focuses on the relationship of alive organisms with their environment.

EARTH SCIENCES

This article has also mentioned earth science as one of the scientific disciplines with the general responsibility of studying the earth and its attributes and activities. It encompasses geology, palaeontology, environmental studies, seismology, geography, and all is classified as earth science. When one studies the earthly sciences regarding territoriality, one gets the chance to see the scale of territoriality that modern architectural practice assumes. Such cases include the current half of the growing world populations living in only one percent of the geographical land, and in other cases, such as populations dwelling in flood plains, coastal planes, or up hillsides, contingencies that result in cyclic operations of the atmosphere and the surface being dangerous for several varieties of catastrophe. Natural materials have been commonly employed in architecture due to their abundant availability. Stone, lime, and clay are readily available in several regions around the globe, rendering them a rational selection for construction materials.

1. Numerous natural substances exhibit the qualities of being resilient and having a prolonged lifespan. Stone is a robust and long-lasting substance that can endure the effects of weathering and erosion, making it a very suitable option for constructing foundations and walls.
2. Geology plays a crucial role in construction as it occurs either on the surface or underground. The excavation process and foundation type are determined by the ground conditions. Therefore, the study of geology and earth sciences significantly impacts the majority of construction operations as it plays a crucial role in determining its characteristics, form & structure, and expenses of construction.
3. The use of contours and terrain is done in landscaping, basement designing and level differences in architecture.
4. The study of earth sciences also helps the architects and engineers in designing and constructing the structure by providing different factors such as building, water resource development, and urban planning. It provides information on site conditions and material attributes.
5. Seismic zones are utilized to provide design guidelines for structures and infrastructure. The earthquake zoning map is an important tool used by Architects and engineers to devise structures that are capable of withstanding earthquakes.
6. Understanding vernacular architecture highlights the influence of local climate, culture, and resources on design. For instance, the construction of igloos in Arctic climates used the stacking of snow blocks to form curved structures that provided insulation.
7. Laterite is a reddish stone that is created from the compaction of red soil located on the western coastline of India. Laterite stone is widely used in Konkan region of Maharashtra in India, as it is readily available and suitable for the climate.

ASTRONOMY

The fields of architecture and astronomy have had a profound and interconnected relationship since prehistoric times. Astronomy is an interesting branch of natural science that focuses on the study of celestial bodies such as the moon, planets, stars, and universes. It also involves the exploration and understanding of various phenomena that occur beyond Earth's atmosphere. Numerous ancient civilizations have made astronomy their primary scientific focus. Over the years, the study of buildings and their layout has become an integral part of the field of astronomy.

1. In ancient civilizations, the study of astronomy involved a thorough investigation of celestial objects and their paths in the sky, as well as the effects of these paths on living beings on Earth. That is the main source from which the majority of individuals have derived their religious traditions. Even now, our religious structures are constructed based on the astronomical arrangement of stars.
2. The connection between astronomy and building may be traced back to ancient times. Throughout history, global observatories have been established by monarchs and people. Architecture may be utilized as a means to understand astronomy. Examples such as the pyramids of Egypt, the Jantar Mantar, and Stonehenge, etc.



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3. Astronomy stands to gain significant advantages from well-planned architectural environments. Every aspect of our daily existence, including rituals and calendars, is intricately connected to astrology. The government is currently seeking to develop advanced observatories.
4. Climatology is a discipline of astronomy that studies atmospheric science. The practice of orienting and positioning dwellings in accordance with the sun's path and calculating azimuth angles may be traced back to ancient astrology.
5. VastuShashtra is the study of astrology and climatology and it is commonly used in the area of design and construction. It is an old Indian architectural and design approach that prioritizes a harmonious relationship between a building and its occupants.

The structure can be balanced by aligning it with the natural elements and energy forces that surround it. Ancient Indians developed concepts of living in harmony with nature or the natural way of living with the environment.

CONCLUSION

As an interdisciplinary profession, architecture requires architects to have a comprehensive understanding of numerous subjects within the Arts and Sciences. Architects play an important role in the design process by integrating their knowledge of Biology, Chemistry, Physics, Earth sciences, and Astronomy into their designs. As a result, architects must have a good understanding of the natural sciences as a prerequisite for their profession. During the study of architecture, the curriculum primarily incorporates natural sciences into different architectural courses. A thorough understanding of the natural sciences significantly enhances building design solutions, making them more comprehensive, inclusive, and environmentally relevant. In order to make this knowledge of natural sciences applicable to the profession, the students require appropriate guidance on the best way to effectively employ the knowledge.

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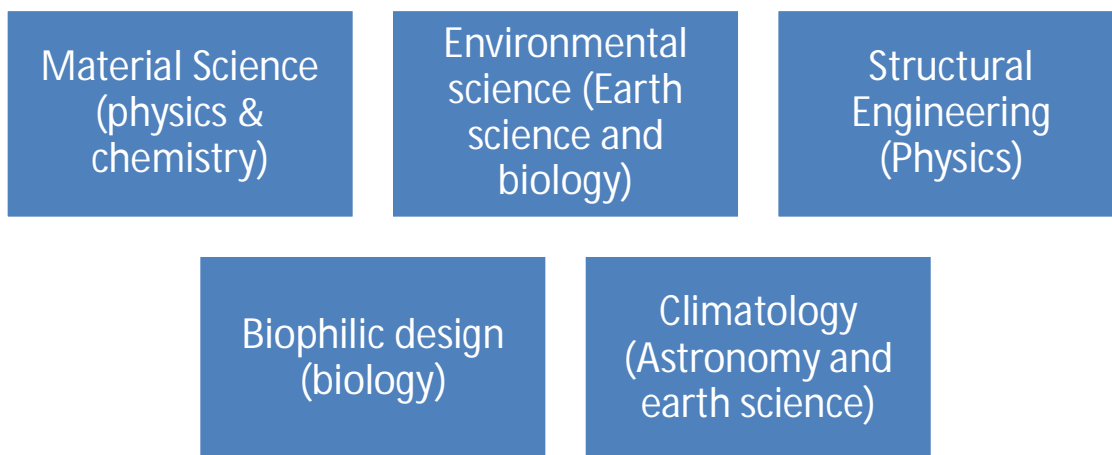


Figure 1: Principle of Architecture and its connection with disciplines of Natural science





A Comparison of Two-Warehouse Inventory Model under Various Scenario

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ABSTRACT

This study focuses on analysing a dual-warehouse inventory model characterized by distinct Holding cost and deterioration quantity. In the rented warehouse, the holding costs are notably high, while the deterioration rate remains relatively low. Conversely, the own warehouse features low holding costs juxtaposed with a high deterioration rate.

Keywords: Dual-warehouse, comparison model, Deterioration rate.

INTRODUCTION

In [1] he discusses about production model where the production is depended on the demand. In [2] the model is for deteriorating items, where all items are not good for all time which is more relate to the real life situation.[3] this is a two warehouse inventory model with a ramp type demand [4] is also a two warehouse inventory model but with production type [6] and [7] also a two warehouse model with exponential demand and first in and first out model respectively this FIFO means that the product are consumed first when they come first. In[9] and [10] the model is for increasing demand this is for newly launched products in the market where it will get a high demand [11] gives variable holding cost which helps for our model to bult. By this we are taking the real life situations as conditions and we bult this model.





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Assumptions

- ❖ $D(t) = a + bt + ct^2$ this is demand which is quadratic.
- ❖ No repair is done in the cycle.
- ❖ Only one item is considered.
- ❖ Both Own warehouse and Rented warehouse has a limited capacity with N and Q units respectively
- ❖ Shortages are not allowed.
- ❖ Two type models are taken for consideration.

Notations:

- ❖ C_o : Ordering Cost
- ❖ C_d : Deterioration Cost
- ❖ h_r : Holding Cost for Rented Warehouse
- ❖ h_o : Holding Cost for Own Warehouse
- ❖ θ_1 : Deterioration Rate of Rented Warehouse
- ❖ θ_2 : Deterioration Rate of Own Warehouse

Mathematical Model:Model: I

This is the normal traditional model. Items in the rented warehouse is consumed first due to the holding cost of Rented warehouse is higher than the holding cost of the Own warehouse ($h_r > h_o$).

As usual Ordering Cost, deterioration cost for both rented warehouse and own warehouse and Holding cost for both RW and OW are calculated.

Then the total cost can be written as

$$\begin{aligned}
 TC_1 = & C_o + h_r \left[\left(Qt - \frac{at_1^2}{2} - \frac{bt_1^3}{6} - \frac{ct_1^4}{12} \right) + a \left\{ \left(\frac{t_1^2+t_2^2-2t_1t_2}{2} \right) - \theta_1 \left(\frac{2t_1^3-t_2^3-3t_1^2t_2}{6} \right) + \frac{\theta_1^2}{2} \left(\frac{3t_1^4+t_2^4-4t_1^3t_2}{12} \right) \right\} + \right. \\
 & f_1 \left\{ \left(\frac{t_1^3+2t_2^3-3t_1t_2^2}{6} \right) - \theta_1 \left(\frac{t_1^4+t_2^4-2t_1^2t_2^2}{8} \right) + \frac{\theta_1^2}{2} \left(\frac{3t_1^5+2t_2^5-5t_1^3t_2^2}{30} \right) \right\} + \\
 & f_2 \left\{ \left(\frac{t_1^4+3t_2^4-4t_1t_2^3}{12} \right) - \theta_1 \left(\frac{2t_1^5+3t_2^5-5t_1^2t_2^3}{30} \right) + \frac{\theta_1^2}{2} \left(\frac{t_1^6+t_2^6-2t_1^3t_2^3}{18} \right) \right\} + \\
 & f_3 \left\{ \left(\frac{t_1^5+4t_2^5-5t_1t_2^4}{20} \right) - \theta_1 \left(\frac{t_1^6+2t_2^6-3t_1^2t_2^4}{24} \right) + \theta_1^2 \left(\frac{(3t_1^7+4t_2^7-7t_1^3t_2^4)}{84} \right) \right\} + f_4 \left\{ \left(\frac{t_1^6+5t_2^6-6t_1t_2^5}{30} \right) - \right. \\
 & \left. \theta_1 \left(\frac{2t_1^7+5t_2^7-7t_1^2t_2^5}{70} \right) + \frac{\theta_1^2}{2} \left(\frac{(3t_1^8+5t_2^8-8t_1^3t_2^5)}{120} \right) \right\} + \\
 & h_o \left[\left[Nt_1 + \frac{N}{\theta_2} (1 - e^{-\theta_2(t_2-t_1)}) \right] + a \left\{ \left(\frac{T^2+t_2^2-2Tt_2}{2} \right) - \theta_2 \left(\frac{2t_2^3+t^3-3t_2^2T}{6} \right) + \frac{\theta_2^2}{2} \left(\frac{3t_2^4+T^4-4t_2^3T}{12} \right) \right\} + \right. \\
 & g_1 \left\{ \left(\frac{t_2^3+2T^3-3t_2T^2}{6} \right) - \theta_2 \left(\frac{t_2^4+T^4-2t_2^2T^2}{8} \right) + \frac{\theta_2^2}{2} \left(\frac{3t_2^5+2T^5-5t_2^3T^2}{30} \right) \right\} + g_2 \left\{ \left(\frac{t_2^4+3T^4-4t_2T^3}{12} \right) - \right. \\
 & \theta_2 \left(\frac{2t_2^5+3T^5-5t_2^2T^3}{30} \right) + \frac{\theta_2^2}{2} \left(\frac{t_2^6+T^6-2t_2^3T^3}{18} \right) \right\} + g_3 \left\{ \left(\frac{t_2^5+4T^5-5t_2T^4}{20} \right) - \theta_2 \left(\frac{t_2^6+2T^6-3t_2^2T^4}{24} \right) + \right. \\
 & \left. \theta_2^2 \left(\frac{(3t_2^7+4T^7-7t_2^3T^4)}{84} \right) \right\} + g_4 \left\{ \left(\frac{t_2^6+5T^6-6t_2T^5}{30} \right) - \theta_2 \left(\frac{2t_2^7+5T^7-7t_2^2T^5}{70} \right) + \frac{\theta_2^2}{2} \left(\frac{(3t_2^8+5T^8-8t_2^3T^5)}{120} \right) \right\} + \\
 & C_d \theta_1 \left[a \left\{ \left(\frac{t_1^2+t_2^2-2t_1t_2}{2} \right) - \theta_1 \left(\frac{2t_1^3-t_2^3-3t_1^2t_2}{6} \right) + \frac{\theta_1^2}{2} \left(\frac{3t_1^4+t_2^4-4t_1^3t_2}{12} \right) \right\} + f_1 \left\{ \left(\frac{t_1^3+2t_2^3-3t_1t_2^2}{6} \right) - \right. \right. \\
 & \left. \theta_1 \left(\frac{t_1^4+t_2^4-2t_1^2t_2^2}{8} \right) + \frac{\theta_1^2}{2} \left(\frac{3t_1^5+2t_2^5-5t_1^3t_2^2}{30} \right) \right\} + \\
 & f_2 \left\{ \left(\frac{t_1^4+3t_2^4-4t_1t_2^3}{12} \right) - \theta_1 \left(\frac{2t_1^5+3t_2^5-5t_1^2t_2^3}{30} \right) + \frac{\theta_1^2}{2} \left(\frac{t_1^6+t_2^6-2t_1^3t_2^3}{18} \right) \right\} + \\
 & f_3 \left\{ \left(\frac{t_1^5+4t_2^5-5t_1t_2^4}{20} \right) - \theta_1 \left(\frac{t_1^6+2t_2^6-3t_1^2t_2^4}{24} \right) + \theta_1^2 \left(\frac{(3t_1^7+4t_2^7-7t_1^3t_2^4)}{84} \right) \right\} + f_4 \left\{ \left(\frac{t_1^6+5t_2^6-6t_1t_2^5}{30} \right) - \right. \\
 & \left. \theta_1 \left(\frac{2t_1^7+5t_2^7-7t_1^2t_2^5}{70} \right) + \frac{\theta_1^2}{2} \left(\frac{(3t_1^8+5t_2^8-8t_1^3t_2^5)}{120} \right) \right\} + C_d \theta_2 \left[\left[\frac{N}{\theta_2} (1 - e^{-\theta_2(t_2-t_1)}) \right] + a \left\{ \left(\frac{T^2+t_2^2-2Tt_2}{2} \right) - \right. \right.
 \end{aligned}$$





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$$\theta_2 \left(\frac{2t_2^3 + t^3 - 3t_2^2 T}{6} \right) + \frac{\theta_2^2}{2} \left(\frac{3t_2^4 + T^4 - 4t_2^3 T}{12} \right) \Bigg\} +$$

$$g_1 \left\{ \left(\frac{t_2^3 + 2T^3 - 3t_2 T^2}{6} \right) - \theta_2 \left(\frac{t_2^4 + T^4 - 2t_2^2 T^2}{8} \right) + \frac{\theta_2^2}{2} \left(\frac{3t_2^5 + 2T^5 - 5t_2^3 T^2}{30} \right) \right\} + g_2 \left\{ \left(\frac{t_2^4 + 3T^4 - 4t_2 T^3}{12} \right) - \right.$$

$$\theta_2 \left(\frac{2t_2^5 + 3T^5 - 5t_2^2 T^3}{30} \right) + \frac{\theta_2^2}{2} \left(\frac{t_2^6 + T^6 - 2t_2^3 T^3}{18} \right) \Bigg\} + g_3 \left\{ \left(\frac{t_2^5 + 4T^5 - 5t_2 T^4}{20} \right) - \theta_2 \left(\frac{t_2^6 + 2T^6 - 3t_2^2 T^4}{24} \right) + \right.$$

$$\theta_2^2 \left(\frac{3t_2^7 + 4T^7 - 7t_2^3 T^4}{84} \right) \Bigg\} + g_4 \left\{ \left(\frac{t_2^6 + 5T^6 - 6t_2 T^5}{30} \right) - \theta_2 \left(\frac{2t_2^7 + 5T^7 - 7t_2^2 T^5}{70} \right) + \frac{\theta_2^2}{2} \left(\frac{3t_2^8 + 5T^8 - 8t_2^3 T^5}{120} \right) \right\}$$

Model: II

In this model all other assumptions are same as the model I. In traditional model deteriorating rate of Own warehouse is higher than the Rented warehouse but here the deterioration cost of own ware house is higher than the holding cost of the Rented warehouse. So items in the Own warehouse is consumed first and then Rented warehouse items will be consumed.

$$\frac{dI_o(t)}{dt} = -D(t) \quad 0 \leq t \leq t_1 \dots\dots\dots (1)$$

$$\frac{dI_o(t)}{dt} = -D(t) - \theta_2 I_o(t) \quad t_1 \leq t \leq t_2 \dots\dots\dots (2)$$

$$\frac{dI_R(t)}{dt} = 0 \quad 0 \leq t \leq t_1 \dots\dots\dots (3)$$

$$\frac{dI_R(t)}{dt} = -\theta_1 I_R(t) \quad t_1 \leq t \leq t_2 \dots\dots\dots (4)$$

$$\frac{dI_R(t)}{dt} = -D(t) - \theta_1 I_R(t) \quad t_2 \leq t \leq T \dots\dots\dots (5)$$

The boundary conditions we have

$$I_R(0) = N, I_o(t_2) = 0, I_o(0) = Q, I_R(t_1) = N, I_R(T) = 0$$

With this boundary condition the equation (1) will become

Then $I_o(t) = -\frac{ct^3}{3} - \frac{bt^2}{2} - at + Q \quad 0 \leq t \leq t_1 \dots\dots\dots (6)$

$$I_o(t) = \left[a(t_2 - t) + \left(\frac{f_1}{2} \right) (t_2^2 - t^2) + \left(\frac{f_2}{3} \right) (t_2^3 - t^3) + \left(\frac{f_3}{4} \right) (t_2^4 - t^4) + \left(\frac{f_4}{5} \right) (t_2^5 - t^5) \right] \cdot e^{-\theta_2 t},$$

$$t_1 \leq t \leq t_2 \quad \dots\dots\dots (7)$$

$$I_R(t) = N \quad 0 \leq t \leq t_1 \quad \dots\dots\dots (8)$$

$$I_R(t) = N \cdot e^{\theta_1(t_1-t)} \quad t_1 \leq t \leq t_2 \quad \dots\dots\dots (9)$$

$$I_R(t) = \left\{ a(T - t) + \left(\frac{g_1}{2} \right) (T^2 - t^2) + \left(\frac{g_2}{3} \right) (T^3 - t^3) + \left(\frac{g_3}{4} \right) (T^4 - t^4) + \left(\frac{g_4}{5} \right) (T^5 - t^5) - t_5 e^{-\theta_1 t} \right\}$$

$$t_2 \leq t \leq T \quad \dots\dots\dots (10)$$

Where the inventory is continuous t_1 and t_2 , we have

At t_1

$$Q = \left[at_1 + \frac{bt_1^2}{2} + \frac{ct_1^3}{3} \right] + \left[a(t_2 - t_1) + \left(\frac{f_1}{2} \right) (t_2^2 - t_1^2) + \left(\frac{f_2}{3} \right) (t_2^3 - t_1^3) + \left(\frac{f_3}{4} \right) (t_2^4 - t_1^4) + \left(\frac{f_4}{5} \right) (t_2^5 - t_1^5) \right] \cdot e^{-\theta_2 t_1}$$

$$\dots\dots\dots (11)$$

At t_2

$$N = \left\{ a(T - t) + \left(\frac{g_1}{2} \right) (T^2 - t^2) + \left(\frac{g_2}{3} \right) (T^3 - t^3) + \left(\frac{g_3}{4} \right) (T^4 - t^4) + \left(\frac{g_4}{5} \right) (T^5 - t^5) \right\} e^{-\theta_1 t_1}$$

$$\dots\dots\dots (12)$$





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Where the maximum inventory is $M=Q+N$

Ordering Cost

$$OC = c_o \dots\dots\dots(13)$$

Holding Cost for Own Warehouse

$$C_{1OW} = h_o \left[\int_0^{t_1} I_o(t)dt + \int_{t_1}^{t_2} I_o(t)dt \right]$$

$$C_{1RW} = h_o \left[\left(Qt - \frac{at_1^2}{2} - \frac{bt_1^3}{6} - \frac{ct_1^4}{12} \right) + a \left\{ \left(\frac{t_1^2+t_2^2-2t_1t_2}{2} \right) - \theta_2 \left(\frac{2t_1^3-t_2^3-3t_1^2t_2}{6} \right) + \frac{\theta_2^2}{2} \left(\frac{3t_1^4+t_2^4-4t_1^3t_2}{12} \right) \right\} + f_1t_1^3+2t_2^3-3t_1t_2^2-\theta_2t_1^4+t_2^4-2t_1t_2^2+2\theta_2t_1^3t_2+2t_2^3-5t_1^3t_2+2t_1^2t_2^2-4t_1t_2^3+2t_2^4-\theta_2^2t_1^5+3t_2^5-5t_1^2t_2^3+\theta_2^2t_1^6+t_2^6-2t_1^3t_2^3+3t_1^5+4t_2^5-5t_1^2t_2^4-2\theta_2t_1^6+2t_2^6-3t_1^2t_2^4+\theta_2^2t_1^7+4t_2^7-7t_1^3t_2^4+f_4t_1^6+5t_2^6-6t_1t_2^5-\theta_2^2t_1^7+5t_2^7-7t_1^2t_2^5+\theta_2^2t_1^8+5t_2^8-8t_1^3t_2^5 \dots\dots\dots(14)$$

Holding cost for Rented Warehouse

$$C_{1RW} = h_r \left[\int_0^{t_1} I_R(t)dt + \int_{t_1}^{t_2} I_R(t)dt + \int_{t_2}^T I_R(t)dt \right]$$

$$C_{1RW} = h_r \left[\left\{ Nt_1 + \frac{N}{\theta_1} (1 - e^{-\theta_1(t_2-t_1)}) \right\} + a \left\{ \left(\frac{T^2+t_2^2-2Tt_2}{2} \right) - \theta_1 \left(\frac{2t_2^3+t^3-3t_2^2T}{6} \right) + \frac{\theta_1^2}{2} \left(\frac{3t_2^4+T^4-4t_2^3T}{12} \right) \right\} + g_1t_2^3+2T^3-3t_2T^2-\theta_1t_2^4+T^4-2t_2T^2+2\theta_1t_2^3T+2T^3-5t_2^3T+g_2t_2^4+3T^4-4t_2T^3-2T^3-2\theta_1t_2^5+3T^5-5t_2^2T^3+\theta_1^2t_2^6+T^6-2t_2^3T^3+g_3t_2^5+4T^5-5t_2^2T^4-\theta_1t_2^6+2T^6-3t_2^2T^4+\theta_1^2t_2^7+4T^7-7t_2^3T^4+g_4t_2^6+5T^6-6t_2^2T^5-\theta_1^2t_2^7+5T^7-7t_2^2T^5+\theta_1^2t_2^8+5T^8-8t_2^3T^5 \dots\dots\dots (15)$$

Deterioration cost for Own Warehouse

$$C_{2OW} = C_d \left(\int_{t_1}^{t_2} \theta_2 I_o(t)dt \right)$$

$$C_{2OW} = C_d \theta_2 \left[a \left\{ \left(\frac{t_1^2+t_2^2-2t_1t_2}{2} \right) - \theta_2 \left(\frac{2t_1^3-t_2^3-3t_1^2t_2}{6} \right) + \frac{\theta_2^2}{2} \left(\frac{3t_1^4+t_2^4-4t_1^3t_2}{12} \right) \right\} + f_1 \left\{ \left(\frac{t_1^3+2t_2^3-3t_1t_2^2}{6} \right) - \theta_2 \left(\frac{t_1^4+t_2^4-2t_1^3t_2}{8} \right) + \frac{\theta_2^2}{2} \left(\frac{3t_1^5+2t_2^5-5t_1^4t_2}{30} \right) \right\} + f_2 \left\{ \left(\frac{t_1^4+3t_2^4-4t_1t_2^3}{12} \right) - \theta_2 \left(\frac{2t_1^5+3t_2^5-5t_1^4t_2}{30} \right) + \frac{\theta_2^2}{2} \left(\frac{t_1^6+t_2^6-2t_1^5t_2}{18} \right) \right\} + \dots\dots\dots$$





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$$f_3 \left\{ \left(\frac{t_1^5 + 4t_2^5 - 5t_1 t_2^4}{20} \right) - \theta_2 \left(\frac{t_1^6 + 2t_2^6 - 3t_1^3 t_2^4}{24} \right) + \theta_2^2 \left(\frac{(3t_1^7 + 4t_2^7 - 7t_1^3 t_2^4)}{84} \right) \right\} + f_4 \left\{ \left(\frac{(t_1^6 + 5t_2^6 - 6t_1 t_2^5)}{30} \right) - \theta_2 \left(\frac{2t_1^7 + 5t_2^7 - 7t_1^2 t_2^5}{70} \right) + \frac{\theta_2^2}{2} \left(\frac{(3t_1^8 + 5t_2^8 - 8t_1^3 t_2^5)}{120} \right) \right\} \dots\dots\dots (16)$$

Deterioration Cost for Rented Warehouse

$$C_{2RW} = C_d \left[\int_{t_1}^{t_2} \theta_1 I_R(t) dt + \int_{t_2}^T \theta_1 I_R(t) dt \right]$$

$$C_{2RW} = C_d \theta_1 \left[\left\{ \frac{N}{\theta_2} (1 - e^{\theta_1(t_2-t_1)}) \right\} + a \left\{ \left(\frac{T^2 + t_2^2 - 2Tt_2}{2} \right) - \theta_1 \left(\frac{2t_2^3 + t^3 - 3t_2^2 T}{6} \right) + \frac{\theta_1^2}{2} \left(\frac{3t_2^4 + T^4 - 4t_2^3 T}{12} \right) \right\} + g_1 t_2^3 + 2T^3 - 3t_2 T^2 - \theta_1 t_2^4 + T^4 - 2t_2 T^2 + 2T^3 - \theta_1 2t_2^3 + 2T^5 - 5t_2 T^2 + 3T^4 - 4t_2 T^3 - \theta_1 2t_2^5 + 3T^5 - 5t_2 T^3 + \theta_1 2t_2^6 + T^6 - 2t_2 T^3 + 3T^5 + g_3 t_2^5 + 4T^5 - 5t_2 T^4 - \theta_1 t_2^6 + 2T^6 - 3t_2 T^4 + \theta_1 2t_2^7 + 4T^7 - 7t_2 T^4 + g_4 t_2^6 + 5T^6 - 6t_2 T^5 - \theta_1 2t_2^7 + 5T^7 - 7t_2 T^5 + \theta_1 2t_2^8 + 5T^8 - 8t_2 T^5 \right] \dots\dots\dots(17)$$

TOTAL COST:

The total cost can be written a

$$TC_2 =$$

$$c_o + h_o \left[\left(Qt - \frac{at_1^2}{2} - \frac{bt_1^3}{6} - \frac{ct_1^4}{12} \right) + a \left\{ \left(\frac{t_1^2 + t_2^2 - 2t_1 t_2}{2} \right) - \theta_2 \left(\frac{2t_1^3 - t_2^3 - 3t_1^2 t_2}{6} \right) + \frac{\theta_2^2}{2} \left(\frac{3t_1^4 + t_2^4 - 4t_1^3 t_2}{12} \right) \right\} + f_1 \left\{ \left(\frac{t_1^3 + 2t_2^3 - 3t_1 t_2^2}{6} \right) - \theta_2 \left(\frac{t_1^4 + t_2^4 - 2t_1^2 t_2^2}{8} \right) + \frac{\theta_2^2}{2} \left(\frac{3t_1^5 + 2t_2^5 - 5t_1^3 t_2^2}{30} \right) \right\} + f_2 \left\{ \left(\frac{t_1^4 + 3t_2^4 - 4t_1 t_2^3}{12} \right) - \theta_2 \left(\frac{2t_1^5 + 3t_2^5 - 5t_1^2 t_2^3}{30} \right) + \frac{\theta_2^2}{2} \left(\frac{t_1^6 + t_2^6 - 2t_1^3 t_2^3}{18} \right) \right\} + f_3 \left\{ \left(\frac{t_1^5 + 4t_2^5 - 5t_1 t_2^4}{20} \right) - \theta_2 \left(\frac{t_1^6 + 2t_2^6 - 3t_1^3 t_2^4}{24} \right) + \theta_2^2 \left(\frac{(3t_1^7 + 4t_2^7 - 7t_1^3 t_2^4)}{84} \right) \right\} + f_4 \left\{ \left(\frac{(t_1^6 + 5t_2^6 - 6t_1 t_2^5)}{30} \right) - \theta_2 \left(\frac{2t_1^7 + 5t_2^7 - 7t_1^2 t_2^5}{70} \right) + \frac{\theta_2^2}{2} \left(\frac{(3t_1^8 + 5t_2^8 - 8t_1^3 t_2^5)}{120} \right) \right\} + h_r \left[Nt_1 + \frac{N}{\theta_1} (1 - e^{\theta_1(t_2-t_1)}) \right] + a \left\{ \left(\frac{T^2 + t_2^2 - 2Tt_2}{2} \right) - \theta_1 \left(\frac{2t_2^3 + t^3 - 3t_2^2 T}{6} \right) + \frac{\theta_1^2}{2} \left(\frac{3t_2^4 + T^4 - 4t_2^3 T}{12} \right) \right\} + g_1 \left\{ \left(\frac{t_2^3 + 2T^3 - 3t_2 T^2}{6} \right) - \theta_1 \left(\frac{t_2^4 + T^4 - 2t_2^2 T^2}{8} \right) + \frac{\theta_1^2}{2} \left(\frac{3t_2^5 + 2T^5 - 5t_2^3 T^2}{30} \right) \right\} + g_2 \left\{ \left(\frac{t_2^4 + 3T^4 - 4t_2 T^3}{12} \right) - \theta_1 \left(\frac{2t_2^5 + 3T^5 - 5t_2^2 T^3}{30} \right) + \frac{\theta_1^2}{2} \left(\frac{t_2^6 + T^6 - 2t_2^3 T^3}{18} \right) \right\} + g_3 \left\{ \left(\frac{t_2^5 + 4T^5 - 5t_2 T^4}{20} \right) - \theta_1 \left(\frac{t_2^6 + 2T^6 - 3t_2^2 T^4}{24} \right) + \theta_1^2 \left(\frac{(3t_2^7 + 4T^7 - 7t_2^3 T^4)}{84} \right) \right\} + g_4 \left\{ \left(\frac{(t_2^6 + 5T^6 - 6t_2 T^5)}{30} \right) - \theta_1 \left(\frac{2t_2^7 + 5T^7 - 7t_2^2 T^5}{70} \right) + \frac{\theta_1^2}{2} \left(\frac{(3t_2^8 + 5T^8 - 8t_2^3 T^5)}{120} \right) \right\} + C_d \theta_2 \left[a \left\{ \left(\frac{t_1^2 + t_2^2 - 2t_1 t_2}{2} \right) - \theta_2 \left(\frac{2t_1^3 - t_2^3 - 3t_1^2 t_2}{6} \right) + \frac{\theta_2^2}{2} \left(\frac{3t_1^4 + t_2^4 - 4t_1^3 t_2}{12} \right) \right\} + f_1 \left\{ \left(\frac{t_1^3 + 2t_2^3 - 3t_1 t_2^2}{6} \right) - \theta_2 \left(\frac{t_1^4 + t_2^4 - 2t_1^2 t_2^2}{8} \right) + \frac{\theta_2^2}{2} \left(\frac{3t_1^5 + 2t_2^5 - 5t_1^3 t_2^2}{30} \right) \right\} + f_2 \left\{ \left(\frac{t_1^4 + 3t_2^4 - 4t_1 t_2^3}{12} \right) - \theta_2 \left(\frac{2t_1^5 + 3t_2^5 - 5t_1^2 t_2^3}{30} \right) + \frac{\theta_2^2}{2} \left(\frac{t_1^6 + t_2^6 - 2t_1^3 t_2^3}{18} \right) \right\} + f_3 \left\{ \left(\frac{t_1^5 + 4t_2^5 - 5t_1 t_2^4}{20} \right) - \theta_2 \left(\frac{t_1^6 + 2t_2^6 - 3t_1^3 t_2^4}{24} \right) + \theta_2^2 \left(\frac{(3t_1^7 + 4t_2^7 - 7t_1^3 t_2^4)}{84} \right) \right\} + f_4 \left\{ \left(\frac{(t_1^6 + 5t_2^6 - 6t_1 t_2^5)}{30} \right) - \theta_2 \left(\frac{2t_1^7 + 5t_2^7 - 7t_1^2 t_2^5}{70} \right) + \frac{\theta_2^2}{2} \left(\frac{(3t_1^8 + 5t_2^8 - 8t_1^3 t_2^5)}{120} \right) \right\} \right] + C_d \theta_1 \left[\left\{ \frac{N}{\theta_2} (1 - e^{\theta_1(t_2-t_1)}) \right\} + a \left\{ \left(\frac{T^2 + t_2^2 - 2Tt_2}{2} \right) - \theta_1 \left(\frac{2t_2^3 + t^3 - 3t_2^2 T}{6} \right) + \frac{\theta_1^2}{2} \left(\frac{3t_2^4 + T^4 - 4t_2^3 T}{12} \right) \right\} + g_1 t_2^3 + 2T^3 - 3t_2 T^2 - \theta_1 t_2^4 + T^4 - 2t_2 T^2 + 2T^3 - \theta_1 2t_2^3 + 2T^5 - 5t_2 T^2 + 3T^4 - 4t_2 T^3 - \theta_1 2t_2^5 + 3T^5 - 5t_2 T^3 + \theta_1 2t_2^6 + T^6 - 2t_2 T^3 + 3T^5 + g_3 t_2^5 + 4T^5 - 5t_2 T^4 - \theta_1 t_2^6 + 2T^6 - 3t_2 T^4 + \theta_1 2t_2^7 + 4T^7 - 7t_2 T^4 + g_4 t_2^6 + 5T^6 - 6t_2 T^5 - \theta_1 2t_2^7 + 5T^7 - 7t_2 T^5 + \theta_1 2t_2^8 + 5T^8 - 8t_2 T^5 \right]$$





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$$\theta_1 \left(\frac{2t_2^3 + t^3 - 3t_2^2 T}{6} \right) + \frac{\theta_1^2}{2} \left(\frac{3t_2^4 + T^4 - 4t_2^3 T}{12} \right) \Bigg\} +$$

$$g_1 \left\{ \left(\frac{t_2^3 + 2T^3 - 3t_2 T^2}{6} \right) - \theta_1 \left(\frac{t_2^4 + T^4 - 2t_2^2 T^2}{8} \right) + \frac{\theta_1^2}{2} \left(\frac{3t_2^5 + 2T^5 - 5t_2^3 T^2}{30} \right) \right\} + g_2 \left\{ \left(\frac{t_2^4 + 3T^4 - 4t_2 T^3}{12} \right) - \right.$$

$$\theta_1 \left(\frac{2t_2^5 + 3T^5 - 5t_2^2 T^3}{30} \right) + \frac{\theta_1^2}{2} \left(\frac{t_2^6 + T^6 - 2t_2^3 T^3}{18} \right) \Bigg\} + g_3 \left\{ \left(\frac{t_2^5 + 4T^5 - 5t_2 T^4}{20} \right) - \theta_1 \left(\frac{t_2^6 + 2T^6 - 3t_2^2 T^4}{24} \right) + \right.$$

$$\theta_1^2 \left(\frac{3t_2^7 + 4T^7 - 7t_2^3 T^4}{84} \right) \Bigg\} + g_4 \left\{ \left(\frac{t_2^6 + 5T^6 - 6t_2 T^5}{30} \right) - \theta_1 \left(\frac{2t_2^7 + 5T^7 - 7t_2^2 T^5}{70} \right) + \frac{\theta_1^2}{2} \left(\frac{3t_2^8 + 5T^8 - 8t_2^3 T^5}{120} \right) \right\}$$

Our primary goal is to reduce the total cost, which requires us to determine the optimal values of t_2 and T . Through the utilization of the Hessian matrix, we identify the optimal solution if it meets our criteria. If it satisfies the condition then (t_2, T) is the optimal solution on TC_1 and in the similar way we have to find the optimal solution for TC_2 where $TC = \min(TC_1, TC_2)$

CONCLUSION

Retailers typically encounter various expenses related to product maintenance, procurement, and warehouse management. It's not always prudent to adhere to a single model; depending on the product and warehouse facility, switching models can effectively reduce the total cost. This paper could be expanded to consider scenarios involving shortages or the storage of multiple items in the warehouse.

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A Pareto based Deterioration Rate Inventory Model with Bi-Quadratic Demand and Shortages

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ABSTRACT

In this paper, an EOQ model for Bi-quadratic time-varying demand with deterioration is developed. Shortages are allowed and they are fully backlogged. It is assumed here that the deterioration rate follows Pareto distribution. Carrying cost, Shortage cost and Deterioration cost for the model are calculated. Optimal time to consume the physical stock, cycle time and total cost from inventory costs are determined. A numerical example is given to discuss the results. To understand the influence of changes in the parameters on the optimal policies a sensitivity analysis of the example is provided.

Keywords: Inventory, Pareto distribution, deterioration rate, shortages, cycle time.

INTRODUCTION

For an efficiency of an organization and its smooth conduct, physical resources are kept in stock. This is called the Inventory. Researchers consider the demand of the decaying resources as linearly time dependent or constant or exponential. Also at the end of the life period of the inventory deterioration takes place. The process that prevents an item from usage is deterioration. An item in stock can deteriorate over time as it cannot be used further or because of its demand gets decreasing. Covert et al. [1], Jalan A K et al. [2] and Chakrabarty et al. [3] first considered the deterioration rate as a Weibull distribution and trended demand for inventory models. In the year 2019, Singh N, Vaish B and Singh S R [4] framed an EOQ model with deterioration following Pareto distribution having a demand of trapezoidal type with fully backlogged. Sanni and Chukwu [5] extended the Weibull distribution deterioration





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rate for three parameters with a ramp-type demand. An inventory model for three-parameter Weibull distributed deterioration rate under inflation was developed by Akaninyene Udo Udom et al. [6] in the year 2022.

Pareto Distribution

Multivariate Pareto Distributions was first introduced by Mardia [7] in the year 1962. If a random variable X follows Pareto Distribution, then its probability density function is given by $f(x) = \frac{\alpha\beta^\alpha}{x^{\alpha+1}}$ with $\alpha > 0$ being the shape parameter, scale parameter $\beta > 0$ and $x \geq \beta$ and its cumulative distribution function is given by $F(x) = 1 - \left(\frac{\beta}{x}\right)^\alpha$. Pareto distribution is a left-skewed distribution with high top tail. This is observed in the case of degraded food materials. In this paper, an inventory model for analysis of procurement of degraded food materials, is developed assuming that its deterioration rate follows Pareto distribution and Bi-Quadratic type time varying demand. This EOQ model allows shortages and they are fully backlogged. Optimal time to consume the resources, optimum cycle time, optimum total cost are evaluated. A numerical example is used to prove the result and the sensitivity analysis for the data is also studied. MATLAB software is used to find the optimum values.

THE MATHEMATICAL MODEL

NOTATIONS

The proposed model contains the following parameters and decision variables.

Parameters

A -Ordering cost

h -Holding cost

Q_d -number of deteriorated units

Q -Initial stock

Q^* -Optimal Order Quantity

s -Shortage cost

θ -Deterioration rate

$D(t)=a+bt+ct^2+dt^3+ft^4$ -Demand rate where a,b,c,d,f are constants

$I(t)$ -Inventory level at time t

Z -Total cost per cycle

Z^* -Optimum Total cost per cycle

q_1 -Maximum stock level

q_2 -Maximum stock shortage level

C -Deterioration cost

Decision variables

T -Cycle time

T^* -Optimum Cycle time

T_1 -Time of positive stock

T_1^* -Optimum Time of positive stock

ASSUMPTIONS

1. The rate of replenishment is infinite
2. The inventory model deals with single item
3. Demand rate $D(t)=a+bt+ct^2+dt^3+ft^4$ is assumed to be Bi-Quadratic, where a,b,c,d,f are constants
4. Shortages are allowed and they are backlogged
5. Lead time is zero
6. The deterioration rate follows Pareto distribution

Thus the deterioration rate is given by

$$\theta(t) = \frac{f(t)}{1-F(t)} = \frac{\alpha}{t}$$





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MODEL FORMULATION

The objective of the inventory model is to maintain a minimum total cost by determining the optimal order quantity and optimum cycle time. At time $t = 0$, it is found the inventory level is maximum of $q1$. At time T_1 , inventory level is 0, and at $t = T$, it reaches the the maximum shortage level $q2$.

Thus the inventory level $I(t)$ can expressed as the differential equations

$$\frac{dI(t)}{dt} + \theta(t)I(t) = -D(t) \quad 0 \leq t \leq T_1 \tag{1}$$

$$\frac{dI(t)}{dt} = -D(t) \quad T_1 \leq t \leq T \tag{2}$$

The solution of the equation (1) with $I(T_1) = 0$ is given by

$$I(t) = \frac{a}{\alpha+1}(T_1 - t) + \frac{b}{\alpha+2}(T_1^2 - t^2) + \frac{c}{\alpha+3}(T_1^3 - t^3) + \frac{d}{\alpha+4}(T_1^4 - t^4) + \frac{f}{\alpha+5}(T_1^5 - t^5) \tag{3}$$

where $0 \leq t \leq T_1$.

At time $t = 0, I(t) = q1$. Hence

$$q1 = \frac{a}{\alpha+1}T_1 + \frac{b}{\alpha+2}T_1^2 + \frac{c}{\alpha+3}T_1^3 + \frac{d}{\alpha+4}T_1^4 + \frac{f}{\alpha+5}T_1^5 \tag{4}$$

The solution of the equation (2) with $I(T_1) = 0$ is given by

$$I(t) = a(T_1 - t) + \frac{b}{2}(T_1^2 - t^2) + \frac{c}{3}(T_1^3 - t^3) + \frac{d}{4}(T_1^4 - t^4) + \frac{f}{5}(T_1^5 - t^5) \tag{5}$$

At time $t = 0, I(t) = q2$. Hence, the maximum shortage quantity is

$$q2 = a(T - T_1) + \frac{b}{2}(T^2 - T_1^2) + \frac{c}{3}(T^3 - T_1^3) + \frac{d}{4}(T^4 - T_1^4) + \frac{f}{5}(T^5 - T_1^5) \tag{6}$$

Thus the initial order quantity

$$Q = q1 + q2$$

$$Q = -\alpha \left(\frac{a}{\alpha+1}T_1 + \frac{b}{2(\alpha+2)}T_1^2 + \frac{c}{3(\alpha+3)}T_1^3 + \frac{d}{4(\alpha+4)}T_1^4 + \frac{f}{5(\alpha+5)}T_1^5 \right) + aT + \frac{b}{2}T^2 + \frac{c}{3}T^3 + \frac{d}{4}T^4 + \frac{f}{5}T^5 \tag{7}$$

The Holding cost (HC) of the inventory model is

$$HC = h \int_0^{T_1} I(t)dt$$

$$HC = h \left[\frac{a}{\alpha+1} \left(\frac{T_1^2}{2} \right) + \frac{b}{\alpha+2} \left(\frac{2T_1^3}{3} \right) + \frac{c}{\alpha+3} \left(\frac{3T_1^4}{4} \right) + \frac{d}{\alpha+4} \left(\frac{4T_1^5}{5} \right) + \frac{f}{\alpha+5} \left(\frac{5T_1^6}{6} \right) \right] \tag{8}$$

The Shortage cost (SC) in the interval $[T_1, T]$ is given by

$$SC = -s \int_{T_1}^T I(t)dt$$

$$SC = \frac{as}{2}(T^2 + T_1^2) + \frac{bs}{6}(T^3 + 2T_1^3) + \frac{cs}{12}(T^4 + 3T_1^4) + \frac{ds}{20}(T^5 + 4T_1^5) + \frac{fs}{30}(T^6 + 5T_1^6) - asT_1T - \frac{bs}{2}T_1^2T - \frac{cs}{3}T_1^3T - \frac{ds}{4}T_1^4T - \frac{fs}{5}T_1^5T \tag{9}$$

The Deterioration cost (DC) of the model is calculated by

$$DC = C \left[Q - \int_0^{T_1} D(t)dt \right]$$

Hence

$$DC = C \left[\frac{\alpha+2}{\alpha+1}(aT_1) + \frac{\alpha+4}{2(\alpha+2)}(bT_1^2) + \frac{\alpha+6}{3(\alpha+3)}(cT_1^3) + \frac{\alpha+8}{4(\alpha+4)}(dT_1^4) + \frac{\alpha+10}{5(\alpha+5)}(fT_1^5) - a(T_1 + T) - \frac{b}{2}(T_1^2 + T^2) - \frac{c}{3}(T_1^3 + T^3) - \frac{d}{4}(T_1^4 + T^4) - \frac{f}{5}(T_1^5 + T^5) \right] \tag{10}$$

Total cost per unit time for the model is

$$Z(T_1, T) = \frac{1}{T} [A + HC + SC + DC]$$

Optimum values of T^* and T_1^* are obtained by solving the differential equations

$$\frac{\partial Z(T_1, T)}{\partial T} = 0 \text{ and } \frac{\partial Z(T_1, T)}{\partial T_1} = 0.$$

The obtained values are minimum if

$$\frac{\partial^2 Z(T_1, T)}{\partial T^2} \frac{\partial^2 Z(T_1, T)}{\partial T_1^2} - \left(\frac{\partial^2 Z(T_1, T)}{\partial T \partial T_1} \right)^2 > 0$$





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Using MATLAB, the optimum values of T^* , T_1^* and $Z^*(T, T_1)$ are calculated.

NUMERICAL EXAMPLE

Applying the following data for the inventory model,

$a = 10, b = 4, c = 4, d = 3, f = 1, h = \text{€}4$ per unit, $s = \text{€}15$ per unit, $A = \text{€}1000$,
 $C = \text{€}10$ per unit, $\alpha = 1$

The optimum values obtained using MATLAB software are

$T^* = 2.8211, T_1^* = 0.8884, Q^* = 152.0010$ and $Z^* = 341.8539$

RESULTS AND DISCUSSIONS

SENSITIVITY ANALYSIS

Based on the changes of parameter values for the above data, the Table 4.1 gives the sensitivity analysis.

From Table 4.1, the variations of T^*, T_1^* are very slow when the parameter purchasing cost A is varied. But Q^* varies moderately and total cost varies rapidly. In the segment 2, the parameter ' a ' is varied from 8 to 12. Because of this variation T^*, T_1^* , Q^* varies moderately while Z^* varies rapidly. It is seen that as ' a ' varies from 8 to 12, Z^* varies from 337.8953 to 345.0636. Similar kind of changes are noticed for the change in parameter value ' b ' and ' c '. The segments 5 and 6 of the table show the sensitivity analysis of the parameters d and f . For both these parameters it is found that there is gradual increase in the optimum values of T^*, T_1^* but a rapid increase in Q^* and Z^* . Further, the shortage cost ' s ' is varied from 13 to 17 in the interval of 1 unit. Gradual decrease of the optimum values T^*, T_1^* with decreasing Q^* and increasing total cost. The same type of changes is noted down for the parameter change of holding cost. That is, as h increases from 2 to 6, T^* decreases from 2.8761 to 2.7995, T_1^* varies from 1.1206 to 0.7733, optimum order quantity keeps decreasing from 160.4972 to 148.9056 but total cost increases from 314.7016 to 354.7950. By noticing the change in deterioration cost C , its increase in its value gives a gradual increase in T^*, T_1^* , a moderate increase in Q^* but a rapid decrease in Z^* . The last segment of the table shows the changes in the parameter α . Due to the this change there is a gradual decrease in T^*, T_1^* , Q^* and a gradual increase in Z^* .

CONCLUSION

In this paper, a new inventory model with Pareto distribution deterioration rate and Bi-Quadratic demand is developed. The model allows shortages which are backlogged. The Holding cost, Shortage cost, Deterioration cost are found in this model. By using these costs, Total cost is evaluated. Using MATLAB, optimum cycle time, optimum time for positive cost, optimum order quantity and optimum total cost are evaluated for a data. The sensitivity analysis for varying the parameters is given and its changes are discussed.

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Table 1: Sensitivity Analysis

Parameters	Parameter values	T^*	T_1^*	Q^*	$Z^*(T, T_1)$
<i>A</i>	980	2.8125	0.8868	150.4216	334.7536
	990	2.8168	0.8876	151.2128	338.3065
	1000	2.8211	0.8884	152.0010	341.8539
	1010	2.8254	0.8892	152.7862	345.3958
	1020	2.8297	0.8901	153.5685	348.9324
<i>a</i>	8	2.8528	0.8631	153.2681	337.8953
	9	2.8370	0.8764	152.6247	339.9738
	10	2.8211	0.8884	152.0010	341.8539
	11	2.8054	0.8994	151.3976	343.5471
	12	2.7897	0.9094	150.8150	345.0636
<i>b</i>	2	2.8742	0.8968	153.9574	333.3790
	3	2.8474	0.8927	152.9377	337.7186
	4	2.8211	0.8884	152.0010	341.8539
	5	2.7954	0.8840	151.1445	345.7923
	6	2.7702	0.8794	150.3653	349.5410
<i>c</i>	2	2.9007	0.9267	150.8067	336.5952
	3	2.8594	0.9069	151.2959	339.4848
	4	2.8211	0.8884	152.0010	341.8539
	5	2.7857	0.8712	152.8905	343.7641
	6	2.7529	0.8550	153.9378	345.2683
<i>d</i>	1	2.8956	0.9589	130.6074	354.0735
	2	2.8539	0.9199	141.3417	348.3461
	3	2.8211	0.8884	152.0010	341.8539
	4	2.7945	0.8623	162.5821	334.8191
	5	2.7723	0.8402	173.0897	327.3814
<i>f</i>	1	2.8211	0.8884	152.0010	341.8539
	2	2.8797	0.8682	202.8362	306.2476
	3	2.9254	0.8510	258.1586	269.2730
	4	2.9610	0.8359	316.5277	231.3258
	5	2.9891	0.8224	376.9741	192.6735
<i>s</i>	13	3.1385	0.8918	220.6451	263.9420
	14	2.9633	0.8892	180.0964	306.5110
	15	2.8211	0.8884	152.0010	341.8539
	16	2.7036	0.8891	131.6517	371.9925
	17	2.6048	0.8907	116.3559	398.2306
<i>h</i>	2	2.8761	1.1206	160.4972	314.7016
	3	2.8406	0.9788	154.9156	331.4582
	4	2.8211	0.8884	152.0010	341.8539





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	5	2.8085	0.8234	150.1746	349.2015
	6	2.7995	0.7733	148.9056	354.7950
C	7	2.4484	0.8392	95.6469	477.0748
	8	2.5540	0.8523	109.3975	436.6659
	9	2.6770	0.8686	127.5328	391.9993
	10	2.8211	0.8884	152.0010	341.8539
	11	2.9901	0.9124	185.6799	284.5394
r	1	2.8211	0.8884	152.0010	341.8539
	2	2.8080	0.8503	148.0401	341.3230
	3	2.7984	0.8124	145.7694	343.5018
	4	2.7910	0.7781	144.2996	346.3120
	5	2.7851	0.7477	143.2742	349.1651

Appendix

$$\begin{aligned}
 Z(T_1, T) = & \frac{1}{T} \left[A + h \left[\frac{a}{\alpha+1} \left(\frac{T_1^2}{2} \right) + \frac{b}{\alpha+2} \left(\frac{2T_1^3}{3} \right) + \frac{c}{\alpha+3} \left(\frac{3T_1^4}{4} \right) + \frac{d}{\alpha+4} \left(\frac{4T_1^5}{5} \right) + \frac{f}{\alpha+5} \left(\frac{5T_1^6}{6} \right) \right] + \right. \\
 & \frac{as}{2} (T^2 + T_1^2) + \frac{bs}{6} (T^3 + 2T_1^3) + \frac{cs}{12} (T^4 + 3T_1^4) + \frac{ds}{20} (T^5 + 4T_1^5) + \frac{fs}{30} (T^6 + \\
 & 5T_1^6) - asT_1T - \frac{bs}{2} T_1^2T - \frac{cs}{3} T_1^3T - \frac{ds}{4} T_1^4T - \frac{fs}{5} T_1^5T + C \left[\frac{\alpha+2}{\alpha+1} (aT_1) + \right. \\
 & \left. \frac{\alpha+4}{2(\alpha+2)} (bT_1^2) + \frac{\alpha+6}{3(\alpha+3)} (cT_1^3) + \frac{\alpha+8}{4(\alpha+4)} (dT_1^4) + \frac{\alpha+10}{5(\alpha+5)} (fT_1^5) - a(T_1 + T) - \right. \\
 & \left. \left. \frac{b}{2} (T_1^2 + T^2) - \frac{c}{3} (T_1^3 + T^3) - \frac{d}{4} (T_1^4 + T^4) - \frac{f}{5} (T_1^5 + T^5) \right] \right]
 \end{aligned}$$





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$$\begin{aligned} \frac{\partial Z}{\partial T} = \frac{-1}{T^2} & \left(A + h \left(\frac{aT_1^2}{2(\alpha+1)} + \frac{2bT_1^3}{3(\alpha+2)} + \frac{3cT_1^4}{4(\alpha+3)} + \frac{4dT_1^5}{5(\alpha+4)} + \frac{5fT_1^6}{6(\alpha+5)} \right) \right. \\ & + \left(\frac{as}{2}(T^2 + T_1^2) + \frac{bs}{3} \left(\frac{T^3}{2} + T_1^3 \right) + \frac{cs}{4} \left(\frac{T^4}{3} + T_1^4 \right) + \frac{ds}{5} \left(\frac{T^5}{4} + T_1^5 \right) \right. \\ & + \left. \frac{fs}{6} \left(\frac{T^6}{5} + T_1^6 \right) - asT_1T - \frac{bs}{2}T_1^2T - \frac{cs}{3}T_1^3T - \frac{ds}{4}T_1^4T - \frac{fs}{5}T_1^5T \right) \\ & + C \left(\frac{aT_1(\alpha+2)}{(\alpha+1)} + \frac{bT_1^2(\alpha+4)}{2(\alpha+2)} + \frac{cT_1^3(\alpha+6)}{3(\alpha+3)} + \frac{dT_1^4(\alpha+8)}{4(\alpha+4)} \right. \\ & + \left. \frac{fT_1^5(\alpha+10)}{5(\alpha+5)} - a(T_1+T) - \left(\frac{b}{2} \right) (T_1^2+T^2) - \left(\frac{c}{3} \right) (T_1^3+T^3) \right. \\ & - \left. \left(\frac{d}{4} \right) (T_1^4+T^4) - \left(\frac{f}{5} \right) (T_1^5+T^5) \right) \\ & + \frac{1}{T} \left(asT + \frac{bsT^2}{2} + \frac{csT^3}{3} + \frac{dsT^4}{4} + \frac{fsT^5}{5} - asT_1 - \frac{bs}{2}T_1^2 - \frac{cs}{3}T_1^3 \right. \\ & \left. - \frac{ds}{4}T_1^4 - \frac{fs}{5}T_1^5 + C(-a-bT-cT^2-dT^3-fT^4) \right) \end{aligned}$$

$$\begin{aligned} \frac{\partial Z}{\partial T_1} = \frac{1}{T} & \left(h \left(\frac{aT_1}{\alpha+1} + \frac{2bT_1^2}{\alpha+2} + \frac{3cT_1^3}{\alpha+3} + \frac{4dT_1^4}{\alpha+4} + \frac{5fT_1^5}{\alpha+5} \right) \right. \\ & + (asT_1 + bsT_1^2 + csT_1^3 + dsT_1^4 + fsT_1^5 - asT - bsT_1T - csT_1^2T \\ & - dsT_1^3T - fsT_1^4T) \\ & + C \left(\frac{a(\alpha+2)}{(\alpha+1)} + \frac{bT_1(\alpha+4)}{(\alpha+2)} + \frac{cT_1^2(\alpha+6)}{(\alpha+3)} + \frac{dT_1^3(\alpha+8)}{(\alpha+4)} \right. \\ & \left. + \frac{fT_1^4(\alpha+10)}{(\alpha+5)} - a - bT_1 - cT_1^2 - dT_1^3 - fT_1^4 \right) \end{aligned}$$

$$\begin{aligned} \frac{\partial^2 Z}{\partial T \partial T_1} = \frac{-1}{T^2} & \left(h \left(\frac{aT_1}{\alpha+1} + \frac{2bT_1^2}{\alpha+2} + \frac{3cT_1^3}{\alpha+3} + \frac{4dT_1^4}{\alpha+4} + \frac{5fT_1^5}{\alpha+5} \right) \right. \\ & + (asT_1 + bsT_1^2 + csT_1^3 + dsT_1^4 + fsT_1^5 - asT - bsT_1T - csT_1^2T \\ & - dsT_1^3T - fsT_1^4T) \\ & + C \left(\frac{a(\alpha+2)}{(\alpha+1)} + \frac{bT_1(\alpha+4)}{(\alpha+2)} + \frac{cT_1^2(\alpha+6)}{(\alpha+3)} + \frac{dT_1^3(\alpha+8)}{(\alpha+4)} \right. \\ & \left. + \frac{fT_1^4(\alpha+10)}{(\alpha+5)} - a - bT_1 - cT_1^2 - dT_1^3 - fT_1^4 \right) \end{aligned}$$

$$\begin{aligned} \frac{\partial^2 Z}{\partial T_1^2} = \frac{1}{T} & \left(h \left(\frac{a}{\alpha+1} + \frac{4bT_1}{\alpha+2} + \frac{9cT_1^2}{\alpha+3} + \frac{16dT_1^3}{\alpha+4} + \frac{25fT_1^4}{\alpha+5} \right) \right. \\ & + (as + 2bsT_1 + 3csT_1^2 + 4dsT_1^3 + 5fsT_1^4 - bsT - 2csT_1T \\ & - 3dsT_1^2T - 4fsT_1^3T) \\ & + C \left(\frac{b(\alpha+4)}{(\alpha+2)} + \frac{2cT_1(\alpha+6)}{(\alpha+3)} + \frac{3dT_1^2(\alpha+8)}{(\alpha+4)} + \frac{4fT_1^3(\alpha+10)}{(\alpha+5)} - b \right. \\ & \left. - 2cT_1 - 3dT_1^2 - 4fT_1^3 \right) \end{aligned}$$





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$$\begin{aligned}
 \frac{\partial^2 Z}{\partial T^2} = & \frac{2}{T^3} \left(A + h \left(\frac{aT_1^2}{2(\alpha + 1)} + \frac{2bT_1^3}{3(\alpha + 2)} + \frac{3cT_1^4}{4(\alpha + 3)} + \frac{4dT_1^5}{5(\alpha + 4)} + \frac{5fT_1^6}{6(\alpha + 5)} \right) \right. \\
 & + \left(\frac{as}{2}(T^2 + T_1^2) + \frac{bs}{3} \left(\frac{T^3}{2} + T_1^3 \right) + \frac{cs}{4} \left(\frac{T^4}{3} + T_1^4 \right) + \frac{ds}{5} \left(\frac{T^5}{4} + T_1^5 \right) \right. \\
 & + \left. \frac{fs}{6} \left(\frac{T^6}{5} + T_1^6 \right) - asT_1T - \frac{bs}{2}T_1^2T - \frac{cs}{3}T_1^3T - \frac{ds}{4}T_1^4T - \frac{fs}{5}T_1^5T \right) \\
 & + C \left(\frac{aT_1(\alpha + 2)}{(\alpha + 1)} + \frac{bT_1^2(\alpha + 4)}{2(\alpha + 2)} + \frac{cT_1^3(\alpha + 6)}{3(\alpha + 3)} + \frac{dT_1^4(\alpha + 8)}{4(\alpha + 4)} \right. \\
 & + \left. \frac{fT_1^5(\alpha + 10)}{5(\alpha + 5)} - a(T_1 + T) - \left(\frac{b}{2} \right) (T_1^2 + T^2) - \left(\frac{c}{3} \right) (T_1^3 + T^3) \right. \\
 & - \left. \left(\frac{d}{4} \right) (T_1^4 + T^4) - \left(\frac{f}{5} \right) (T_1^5 + T^5) \right) \\
 & - \frac{2}{T^2} \left(asT + \frac{bsT^2}{2} + \frac{csT^3}{3} + \frac{dsT^4}{4} + \frac{fsT^5}{5} - asT_1 - \frac{bs}{2}T_1^2 - \frac{cs}{3}T_1^3 \right. \\
 & - \left. \frac{ds}{4}T_1^4 - \frac{fs}{5}T_1^5 + C(-a - bT - cT^2 - dT^3 - fT^4) \right) \\
 & + \frac{1}{T} (as + bsT + csT^2 + dsT^3 + fsT^4 \\
 & + C(-b - 2cT - 3dT^2 - 4fT^3))
 \end{aligned}$$





Homogeneous-Heterogeneous Enactment in Blood-Based Carreau Nanofluid Flow through a Non-Linear Stretching Cylinder: A Fuzzy Volume Proportion Modeling

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ABSTRACT

The primary goal of this analysis is to examine the effects of a spontaneously transferring nanofluid. The base fluid used is a Carreau fluid (Blood), and the nanoparticle used is Titanium dioxide (TiO_2). The fluid moves through a cylinder that has been stretched in a fuzzy ambiguous context. To operate an equivalent transformation, the governing equations for physical domains are transformed from a set of partial differential equations (PDE) to ordinary differential equations (ODE). The MATLAB software was used to solve the following set of equations using the bvp5c technique. The exact volume of nanoparticles (TiO_2) is uncertain and is represented by TFNs (triangular fuzzy numbers) [0, 0.05, 0.1]. The triangular membership function (TMF) is employed to analyze the dissimilarities of ambiguity, when the α -cut is utilized to regulate the Fuzzy Numbers (TFNs). Comparison of crisp and fuzzy numbers for accurate numerical results. Tables and graphs are employed to present the results.

Keywords: Buongiorno, Power law index number, TFN, TMFs, FN, α -cut, bvp5c





INTRODUCTION

Scientists and engineers are becoming more fascinated with through conduction flow in nature because of its extensive applications in several fields, including heat transfer devices, refrigeration, insulation, solar energy gathering, chemical catalysts power plants, nuclear material repositories, petrochemical ponds, and more. Many researchers have utilized natural convection to investigate the flow of Newtonian fluid or non-Newtonian fluid through different geometric regions. In recent decades, numerous efforts have been made in scientific literature to provide precise definitions for the thermo physical characteristics of viscous fluids. These efforts have included the exploration of concepts related to Fuzzification and the study of heat transfer on stretched surfaces. Malik et al [1] investigated the relationship between pressure and the viscosity of Carreau fluid as it passed through a porous media. Megahed et al [2] explored the numerical resolution for the movement of a Newtonian fluid across a non-porous stretched surface by a power law indexed momentum; slide boundary momentum, and changing substantial amounts. Ellahi et al [3] study focused on the theoretical analysis of the peristaltic motion of a Jeffrey fluid in a rectangular conduit that is not uniform, taking into account the effects of ion slip and hall. Mukhopadhyay et al [4] explored the slide flow behavior of a magnetohydrodynamic (MHD) viscous fluid across a cylinder under stretched. They hypothesized that the Slip and magnetic parameters cause a decrease in velocity. Hussain et al [5] investigated the consequences of viscous loss of energy and Joule heating on the flow of magneto hydrodynamic Sisko nanofluid across a stretched cylinder. They proposed that MHD is responsible for regulating the velocity boundary layer and is employed for fluid heating purposes. Shaw et al [6] explored the effect of uniform-diverseremarks in micropolar fluid flow over a sheet that is being stretched or shrunk. It is widely accepted that homogeneous-heterogeneous reactions lead to a decrease in the potency of the reacting substances. Hayat et al [7] the effect of homogeneous/heterogeneous responses on MHD motion of fluid over an extending cylinder were examined.

They discovered the concentrations at the region drops as heterogeneous reactions are strengthened; these have an inverse connection with mass diffusivity. Merkin [8] studied the consequences of insufficient reactants on the flow of the boundary layer, both in a uniform manner and with variations in composition. Due to the formation of a reduced reactant surface layer, the homogeneous reaction takes place. It has been found that the outside response is an excellent method for differentiating the edge. Eman [9] investigated a hybrid methodology that utilized fuzzy differential equations (FDE) and devised an intrinsic technique to solve n^{th} order FDE employing distinguishing characteristics concept. Hang et al [10] explained the basic principle of derivatives of fuzzy. Kaleva [11] introduced the concept of fuzzy differential equations (FDEs). Zadeh [12] The FST was first exhibited in 1965. FST, or Fuzzy Set Theory, is a highly efficient approach for representing scenarios that involve uncertain or imprecise data. Dubois et al [13] the utilization of fuzzy numbers to solve FDEs has gained significant importance in the field of fluid motion in recent times. The study aims to utilize the mathematical approach by $p5c$ to analyze the flow of nanofluid described by modified Buongiorno simulation around a cylinder that extends linearly influenced by an indistinct external magnetic field. The Carreau fluid model is used to represent the base fluid, which in this case is blood. The nanoparticle being studied is Titanium dioxide (TiO_2). An investigation is conducted on the influence of the, Prandtl, Schmidt numbers and Weissenberg, as well as the volume percentage of nanoparticles, on the velocity, temperature, and concentration field. A recent finding has revealed that the addition of nanofluid has a substantial impact on the momentum and energy efficiency of the base fluid. This analysis additionally examined the volume proportion of nanoparticle as an unspecified limiting factor, utilizing FN or TFN. The FDEs with the α -cut approach is utilized to address convection in a fuzzy atmosphere.

Basics of Fuzzy concept

This part offers a comprehensive explanation of fuzzy qualities that can be used for subsequent calculations.

Definition 1 A fuzzy set is an assortment of arranged pairs that satisfy a certain condition.

$\bar{A} = \{(\eta, \mu_{\bar{A}}(\eta)) : \eta \in X, \mu_{\bar{A}}(\eta) \in [0, 1]\}$. A mapping function is defined as $\mu_{\bar{A}}(\eta) : X \rightarrow [0, 1]$, X is the all-encompassing set, and $\mu_{\bar{A}}(\eta)$ membership function of \bar{A} .





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Definition 2 A crisp set A_α is specified as a subset of the α -Cut fuzzy set $\bar{A}_{A_\alpha} = \{\eta/\mu_{\bar{A}}(\eta) \geq \alpha\}$, $0 \leq \alpha \leq 1$.

Definition 3 TFN $\bar{A} = (q_1, q_2, q_3)$ with membership function $\mu_{\bar{A}}(\eta)$ is

$$\mu_{\bar{A}}(\eta) = \begin{cases} \frac{\eta - q_1}{q_2 - q_1}, & \text{for } q_1 \leq \eta \leq q_2 \\ \frac{q_3 - \eta}{q_3 - q_2}, & \text{for } q_2 \leq \eta \leq q_3 \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

The α -cut approach is used to transform a TFN with a maximum (or middle point) q_2 , right length $q_3 - q_2 > 0$, and left length $b_2 - b_1 > 0$ into interval numbers, which are then written as $\bar{A} = [f'_1(\eta; \alpha), f'_2(\eta; \alpha)]; [\theta_1(\eta; \alpha), \theta_2(\eta; \alpha)] = [q_1 + (q_2 - q_1)\alpha, q_3 - (q_3 - q_2)\alpha]$, where α is a value between 0 and 1. An essential part of fuzzy set theory, the membership function defines the membership function. The α -cut membership function and triangular fuzzy numbers $\bar{A} = (q_1, q_2, q_3)$ are shown in Figure 1. An arbitrarily generated triangular fuzzy number satisfying the conditions given below

- (i) $f'_1(\eta; \alpha)$ and $\theta_1(\eta; \alpha)$ are an developing function on $[0, 1]$.
- (ii) $f'_2(\eta; \alpha)$ and $\theta_2(\eta; \alpha)$ are a diminishing function on $[0, 1]$.
- (iii) $f'_1(\eta; \alpha) \leq f'_2(\eta; \alpha)$ and $\theta_1(\eta; \alpha) \leq \theta_2(\eta; \alpha)$ on $[0, 1]$.
- (iv) $f'_1(\eta; \alpha), f'_2(\eta; \alpha), \theta_1(\eta; \alpha)$ and $\theta_2(\eta; \alpha)$ are defined at $[0, 1]$.
- (v) If $f'_1(\eta; \alpha) = f'_2(\eta; \alpha) = f(\eta)$ and $\theta_1(\eta; \alpha) = \theta_2(\eta; \alpha) = \theta(\eta)$, where $f(\eta)$ and $\theta(\eta)$ are a crisp velocity and crisp temperature respectively.

Mathematical formulation

An applied transverse magnetic (B_0) that is constant was used to submit a modified Buongiorno framework to the incompressible flow of an MHD Carreau nanofluid. An elongated cylinder exhibiting homogeneous-heterogeneous reactions It is done by applying a standard magnetic field (B_0) to the cylinder. In terms of thermal stability, the base fluid and nanoparticle are considered to be indistinguishable. The characteristics of the nanofluid's structure are summarized in Table 1. Based on the presumptions indicated earlier and Merkin [8] theoretical concepts, simple manipulation heterogeneous-homogeneous responses can be expressed in the following manner. Figure 2 illustrates the physical model of the flow system.



On the catalyst surface, a first-order isothermal reaction is taking place.



In this case, l_c and l_s are the constants rate, and p and q are the quantities of the chemical kinds. It is believed that both reactions are isothermal. It was possible to generate the model regulating equation after using the common boundary layer perspective.

$$\frac{\partial}{\partial x}(ru) + \frac{\partial}{\partial r}(rv) = 0 \quad (4)$$

$$u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial r} = \frac{\mu_{nf}}{\rho_{nf}} \frac{1}{r} \frac{\partial}{\partial r} \left[r \frac{\partial u}{\partial r} \right] \left(1 + \Gamma^2 \left(\frac{\partial u}{\partial r} \right)^2 \right)^{\frac{n-1}{2}} + \frac{\mu_{nf}}{\rho_{nf}} (n-1) \Gamma^2 \frac{\partial^2 u}{\partial r^2} \left(\frac{\partial u}{\partial r} \right)^2 \left[1 + \Gamma^2 \left(\frac{\partial u}{\partial r} \right)^2 \right]^{\frac{n-3}{2}} - \frac{\sigma_{nf} B_0^2 u}{\rho_{nf}} \quad (5)$$

$$u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial r} = \frac{k_{nf}}{r(\rho C_p)_{nf}} \frac{\partial}{\partial r} \left[r \frac{\partial T}{\partial r} \right] + \tau \left[D_B \frac{\partial b}{\partial r} \frac{\partial T}{\partial r} + \frac{D_T}{T_\infty} \left(\frac{\partial T}{\partial r} \right)^2 \right] \quad (6)$$

$$u \frac{\partial a}{\partial x} + v \frac{\partial a}{\partial r} = D_A \left[\frac{\partial^2 a}{\partial r^2} + \frac{\partial a}{\partial r} \right] + D_B \frac{\partial b}{\partial r} + \frac{D_T}{T_\infty} \frac{\partial T}{\partial r} - p_c a b^2 \quad (7)$$

$$u \frac{\partial b}{\partial x} + v \frac{\partial b}{\partial r} = D_B \left[\frac{\partial^2 b}{\partial r^2} + \frac{\partial b}{\partial r} \right] + D_B \frac{\partial b}{\partial r} + \frac{D_T}{T_\infty} \frac{\partial T}{\partial r} + p_s a b^2 \quad (8)$$

For the Equations (4)– (8), The following is an explicit definition of the boundary conditions::

$$u = u(x), \quad v = 0, \quad D_A \frac{\partial a}{\partial r} = l_c a, \quad D_B \frac{\partial b}{\partial r} = -l_s b, \quad T = T_w, \quad D_B \frac{\partial b}{\partial r} + \frac{D_T}{T_\infty} \frac{\partial T}{\partial r} = 0 \text{ at } r = R, u \rightarrow 0, T \rightarrow T_\infty, a \rightarrow a_\infty, b \rightarrow b_\infty \text{ as } r \rightarrow \infty \quad (9)$$

Where $u(x) = \frac{x u_0}{l}$ where u_0 velocity, l is the characteristic length, u (axial direction) and v (radial direction) are velocity elements.





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$D_B \frac{\partial b}{\partial r} + \frac{D_T}{T_\infty} \frac{\partial T}{\partial r} = 0$. It is asserted that the inclusion of thermophoresis results in a lack of movement of nanoparticles at the contact.

$$\rho_{nf} = (1 - \varphi)\rho_f + \varphi\rho_{nf}, \tag{10}$$

$$\mu_{nf} = \frac{\mu_f}{(1-\varphi)^{2.5}}, \tag{11}$$

$$(\rho C_p)_{nf} = (1 - \varphi)(\rho C_p)_f + \varphi(\rho C_p)_n, \tag{12}$$

$$v_{nf} = \frac{\mu_{nf}}{\rho_{nf}}, \quad \alpha_{nf} = \frac{k_{nf}}{(\rho C_p)_{nf}}, \tag{13}$$

$$\sigma_{nf} = \sigma_f \left(1 + \frac{3(\sigma-1)\varphi}{(\sigma+2)-(\sigma-1)\varphi} \right), \quad \sigma = \frac{\sigma_p}{\sigma_f}, \tag{14}$$

$$\frac{k_{nf}}{k_f} = \frac{(2k_f+k_n)-2\varphi(k_f-k_n)}{(2k_f+k_n)+\varphi(k_f-k_n)}, \tag{15}$$

To provide consistency, the stream function $\psi(r, x)$ is added in order to fulfill the continuity equation (3).

$$u = \frac{1}{r} \frac{\partial \psi}{\partial r}, \quad v = -\frac{1}{r} \frac{\partial \psi}{\partial x} \tag{16}$$

Where $\psi = \sqrt{u(x)v_f x} Rf(\eta)$, is the function of the dimensionless stream.

$$\eta = \frac{r^2 - R^2}{2R} \sqrt{\frac{u(x)}{v_f x}}, \quad \theta(\eta) = \frac{T - T_\infty}{T_p - T_\infty} \tag{17}$$

That which follows a depiction of the concentrations of the chemical spices P and Q:

$$m(\eta) = \frac{p}{p_0} \text{ and } n(\eta) = \frac{q}{q_0}, \tag{18}$$

Upon incorporating the designated transformation, the governing equations manifest themselves in the subsequent manner.

$$2D_1 k \left(1 + we^2 (f'')^2 \right)^{\frac{n-1}{2}} + D_1 (1 + 2k\eta) f'' \left(1 + we^2 (f'')^2 \right)^{\frac{n-1}{2}} + D_1 (n-1) we^2 (f'')^3 k \left(1 + we^2 (f'')^2 \right)^{\frac{n-3}{2}} + D_1 (n-1) we^2 (f'')^2 \left(1 + we^2 (f'')^2 \right)^{\frac{n-3}{2}} (1 + 2k\eta) - D_2 D_3 B f' - (f')^2 + f f'' = 0 \tag{19}$$

$$D_5 (1 + 2k\eta) \theta'' + 2k D_4 \theta' + D_4 P r f \theta' + (1 + 2k\eta) [N_b n'(\eta) \cdot \theta'(\eta)] + (1 + 2k\eta) [N_t (\theta'(\eta))^2] = 0, \tag{20}$$

$$\frac{1}{Sc} \left((1 + 2k\eta) m'' + 2km' \right) + m' f - L m n^2 = 0, \tag{21}$$

$$\frac{\delta}{Sc} \left((1 + 2k\eta) n'' + 2kn' \right) + n' f + L m n^2 = 0. \tag{22}$$

The compatible of the boundary conditions.

$$f(0) = 0, \quad \theta(0) = 1, \quad m'(0) = L_s m(0), \quad N_b m'(0) + N_t \theta'(0) = 0, \\ \delta n'(0) = \frac{-L_s n(0)}{v_f}, \quad f'(0) = 1, \quad f'(\infty) = 0, \quad \theta(\infty) = 0, \quad m(\infty) = 1, \quad n(\infty) = 1. \tag{23}$$

In most instances, we anticipate that the coefficients of diffusion of chemical kinds P and Q would be approximately equivalent in size. We assume that the coefficients of diffusion D_A and D_B are equal; meaning that $\delta = 1$.

$$m(\eta) + n(\eta) = 1, \tag{24}$$

Eqs. (21) and (22) are thus transformed into the following expressions.

$$\frac{1}{Sc} \left((1 + 2k\eta) m'' + 2km' \right) + m' f + \frac{N_t}{N_b} [(1 + 2k\eta) \theta''(\eta) + 2k \theta'(\eta)] - L m (1 - m)^2 = 0, \tag{25}$$

Based on the specified boundary conditions

$$m'(0) = L_s m(0), \quad m(\infty) \rightarrow 1. \tag{26}$$

Fuzzification formulation

Small changes in volume fraction of nanoparticle affect momentum and energy. Some researchers utilize the volume fraction of nanoparticles in the vary on [0.01-0.05], presuming flow of fluid is defined under these principles. However, this produces ambiguity. The fuzzy setting, φ denotes the volume fraction of TiO_2 . A fuzzy number should be used for volume fractions in complex scenarios. Fuzzy solutions were created by converting nonlinear ODEs (19), (20), and (25) into FDEs with boundary circumstances through α - cut method.

$$2D_1 k \left(1 + we^2 \left(\frac{d^2}{d\eta^2} [f_1(\eta, \alpha), f_2(\eta, \alpha)] \right)^2 \right)^{\frac{n-1}{2}} + D_1 (1 + 2k\eta) \frac{d^2}{d\eta^2} [f_1(\eta, \alpha), f_2(\eta, \alpha)] \left(1 + we^2 \left(\frac{d^2}{d\eta^2} [f_1(\eta, \alpha), f_2(\eta, \alpha)] \right)^2 \right)^{\frac{n-1}{2}} + D_1 (n-1) we^2 \left(\frac{d^2}{d\eta^2} [f_1(\eta, \alpha), f_2(\eta, \alpha)] \right)^3 k \left(1 + \right.$$





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$$we^2 \left(\frac{d^2}{d\eta^2} [f_1(\eta, \alpha), f_2(\eta, \alpha)] \right)^2 \frac{n-3}{2} + D_1(n-1)we^2 \left(\frac{d^2}{d\eta^2} [f_1(\eta, \alpha), f_2(\eta, \alpha)] \right)^2 \left(1 + we^2 \left(\frac{d^2}{d\eta^2} [f_1(\eta, \alpha), f_2(\eta, \alpha)] \right)^2 \right)^{\frac{n-3}{2}} (1 + 2k\eta) - D_2D_3B \left(\frac{d}{d\eta} [f_1(\eta, \alpha), f_2(\eta, \alpha)] \right) - \left(\frac{d}{d\eta} [f_1(\eta, \alpha), f_2(\eta, \alpha)] \right)^2 + f \frac{d^2}{d\eta^2} [f_1(\eta, \alpha), f_2(\eta, \alpha)] = 0, \tag{27}$$

$$D_5(1 + 2k\eta) \frac{d^2}{d\eta^2} [\theta_1(\eta, \alpha), \theta_2(\eta, \alpha)] + 2kD_4 \frac{d}{d\eta} [\theta_1(\eta, \alpha), \theta_2(\eta, \alpha)] + D_4Prf \frac{d}{d\eta} [\theta_1(\eta, \alpha), \theta_2(\eta, \alpha)] + (1 + 2k\eta) \left[N_b n'(\eta) \frac{d}{d\eta} [\theta_1(\eta, \alpha), \theta_2(\eta, \alpha)] \right] + (1 + 2k\eta) \left[N_t \left(\frac{d}{d\eta} [\theta_1(\eta, \alpha), \theta_2(\eta, \alpha)] \right)^2 \right] = 0, \tag{28}$$

$$\frac{1}{Sc} \left((1 + 2k\eta) \frac{d^2}{d\eta^2} [m_1(\eta, \alpha), m_2(\eta, \alpha)] + 2k \frac{d}{d\eta} [m_1(\eta, \alpha), m_2(\eta, \alpha)] \right) + f \frac{d}{d\eta} [m_1(\eta, \alpha), m_2(\eta, \alpha)] + \frac{N_b}{N_b} \left[(1 + 2k\eta) \frac{d^2}{d\eta^2} [\theta_1(\eta, \alpha), \theta_2(\eta, \alpha)] + 2k \frac{d}{d\eta} [\theta_1(\eta, \alpha), \theta_2(\eta, \alpha)] \right] - Lm(1 - m)^2 = 0. \tag{29}$$

Boundary conditions are compatible with the following:

$$f(\eta, \alpha) = 0, \quad \frac{d}{d\eta} [f_1(\eta, \alpha), f_2(\eta, \alpha)] = 1, \theta(\eta, \alpha) = 1, \\ \frac{d}{d\eta} [m_1(\eta, \alpha), m_2(\eta, \alpha)] = L_s m(\eta, \alpha), \quad N_b \frac{d}{d\eta} [m_1(\eta, \alpha), m_2(\eta, \alpha)] + N_t \frac{d}{d\eta} [\theta_1(\eta, \alpha), \theta_2(\eta, \alpha)] = 0, \\ \frac{d}{d\eta} [f_1(\eta, \alpha), f_2(\eta, \alpha)] = 0, \eta \rightarrow \infty, \theta(\eta, \alpha) = 0, \eta \rightarrow 0, m(\eta, \alpha) = 1, \eta \rightarrow 1. \tag{30}$$

Similar to the velocity of a fuzzy field, here $f'_1(\eta; \alpha)$ represents the lowest limit and $f'_2(\eta; \alpha)$ represents the higher limit, the temperature profile $\theta(\eta; \alpha) = [\theta_1(\eta; \alpha), \theta_2(\eta; \alpha)]$ is also involved. The TFN and crisp values corresponding to these FNs are displayed in Table 2. The variance of FN at every α -cut was ascertained by the TFNs. The TMFs of the FNs are defined as TFNs, and they range from 0 to 1.

RESULTS AND DISCUSSIONS

In the Carreau fluid (Blood) model, T_1O_2 nanoparticles enhance velocity and temperature in a stretched cylinder with a constant power law index. In MATLAB, the numerical technique `bvp5c` solves nonlinear ODEs (19), (20), and (25) with boundary conditions. In Figure 3, we discover elements that significantly impact the triangular fuzzy number value of nanoparticle volume percentage $\varphi = [0,0.05,0.1]$. Those parameters include Weissenberg number (We), curvature (k), magnetic field (B), and the effect of constant power law index number $n = 1.4$ on velocity. Figure 3 (a) As the Weissenberg number (We) and nanoparticle volume percentage grow, the velocity profile decreases for the constant power law index number. Weissenberg number, this is the ratio of the fluid's leisure time to the procedure's frequency time, thickens the fluid and slows velocity. Figure 3 (b) reciprocal relationships between curvature parameter and cylinder radius. As curvature increases, the cylinder's parameter reduces the surface and radius. Thus, fluid movement is less constrained, enhancing velocity. Figure 3 (c) shows how the magnetic (B) impacts Carreau nanofluid momentum for constant power law index number. The figure shows that Carreau nanofluid velocity lowers the magnetic projection. Higher nanoparticle volume proportions and magnetic field parameters indicate stronger Lorentz forces. Carreau nanofluid particles had trouble with resistive forces, which lowered velocity curves. Figure 4 (a) demonstrates the consequences of the Prandtl numeral (Pr) on the energy profile in the absence of boundary permeability. The temperature decreases as Pr increases. Increasing the Prandtl number reduces the thickness ($n = 1.4$) of the boundary circumstances of heat. Figure 4 (b) displays the energy (temperature) reductions for a consistent power law index number for various numerical values of the curvature factor (k). The temperature decreases as the curvature factor enhances due to a decrease in the kinetic energy and velocity of fluid flow. Figure 5 shows how the volume fraction of nanoparticles has an impact on chemically reactive species concentration in constant power law index number, as Schmidt number (Sc) increases. Larger Schmidt number values improve concentration profiles due to reduced mass diffusivity. Now let's discuss the volume fraction of nanoparticle T_1O_2 on Fuzzy ambient. Then nanoparticles volume fractions, as specified in Table 1, are classified as TFN while analyzed through the α -cut approach ($0 \leq \alpha \leq 1$). The volume fraction of TFNs (T_1O_2 nanoparticle) is shown in Figure 7 (refer to Table 2). The values of $f(\eta, \alpha)$ and $\theta(\eta, \alpha)$ are influenced by the α -cut values ($\alpha = 0, 0.3, 0.7, 1$). The lower and upper bounds of the velocity fields in Figure 7(a) correspond to the constant power law index number ($n = 1.4$) for TFNs





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(φ). The upper and lower limits of the nanofluid are $f_1(\eta; \alpha)$ and $f_2(\eta; \alpha)$ when α – cut values. As α – cut increases, the breadth between $f_1(\eta, \alpha)$ and $f_2(\eta, \alpha)$ diminishes, becoming constant at $\alpha = 1$. Similar way Figure 7(b) shows that when α increases the fuzzy temperature $\theta(\eta, \alpha)$, the difference between $\theta_1(\eta, \alpha)$ and $\theta_2(\eta, \alpha)$ reduces, resulting in $\alpha = 1$ consistency.

CONCLUSION

Sequential body velocity, temperature, and concentration profiles for an MHD Carreau nanofluid moving through a stretched cylinder in a fuzzy atmosphere are computed using a modified version of Buongiorno frame work. We discovered. Numerical convergence of the approach was confirmed using predefined parameters. Uncertainty variability is analyzed by the TMF, and TFNs are controlled by the α -cut. When constant power law index number ($n = 1.4$), nanofluid's velocity profile increases along with the Weissenberg numeral increasing behavior. For a constant power law index number ($n = 1.4$), increasing the curvature limiting factor (k) enhances the nanofluid velocity. The nanofluid velocity diminishes as the magnetic field parameter (B) grows with a constant power law index number ($n = 1.4$). For a given fixed power law index number, the temperature of the nanofluid reduces as the Prandtl number (Pr) grows. The impact on fluid temperature decreases for constant power law index number for increasing curvature parameter (k). The concentration profiles increase for constant power law index number when various values of Schmidt number (Sc). Considering the results, the ideal value for α range from 0 to 1, with the assumed perception of the TFN being determined by the constant width of the fuzzy velocity and fuzzy temperature.

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Table 1: The base fluid's and the nanoparticle's thermo physical properties

Thermal properties	$C_p (Jkg^{-1}K^{-1})$	$\rho (kgm^{-3})$	$k (Wm^{-1}K^{-1})$	$\sigma (\Omega^{-1} cm^{-1})$
Blood	3617	1050	0.52	0.667
TiO ₂	690	4250	8.953	2.4×10^6

Table 2: Nomenclature

a and b	Concentrations of nanoparticle
D_A and D_B	Brownian diffusion coefficients
D_T	Thermophoretic diffusion coefficient
$(C_p)_{nf}$	Specific heat of nanofluid
μ_{nf}	Dynamic viscosity of nanofluid
ρ_{nf}	Density of nanofluid
$(\rho C_p)_{nf}$	Heat capacity of nanofluid
ν_{nf}	Kinematic viscosity nanofluid
k_{nf}	Thermal conductivity of nanofluid
σ_{nf}	Electrical conductivity of nanofluid
α_{nf}	Thermal diffusivity of nanofluid
ρ_f	Density of base fluid
μ_f	Viscosity of base fluid
k_f	Thermal conductivity of the base fluid
ϕ	Nanoparticle volume fraction
n	Power law index
$\tau = \frac{(\rho C)_f}{(\rho C)_p}$	Fluid heat capacity

Table 3: The compatible of the boundary conditions.

D_1	$\frac{1}{(1 - \phi)^{2.5} \left(1 - \phi + \left(\frac{\phi \rho_n}{\rho_f} \right) \right)}$
D_2	$1 + \frac{3 \left(\frac{\sigma_p}{\sigma_f} - 1 \right) \phi}{\left(\frac{\sigma_p}{\sigma_f} + 2 \right) - \left(\frac{\sigma_p}{\sigma_f} - 1 \right) \phi}$
D_3	$\frac{1}{\left(1 - \phi + \left(\frac{\phi \rho_n}{\rho_f} \right) \right)}$
D_4	$\left(1 - \phi + \frac{\phi (\rho C_p)_n}{(\rho C_p)_f} \right)$
D_5	$\frac{(2k_f + k_n) - 2\phi(k_f - k_n)}{(2k_f + k_n) + \phi(k_f - k_n)}$

Table 4: Non-dimensional numerals

Curvature Parameter	k	$\frac{1}{R} \sqrt{\frac{\nu_f l}{u_0}}$
Weissenberg number	We	$\frac{\tau^2 r^2 u_0^3 x^2}{l^3 \nu_f}$





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Magnetic field parameter	B	$\frac{\sigma B_0^2}{\rho_f a}$
Prandtl number	Pr	$\frac{v_f}{\alpha}$
Schmidt number	Sc	$\frac{v_f}{D_A}$
Ratio diffusion coefficients	δ	$\frac{D_B}{D_A}$
Brownian motion limiting factor	N_b	$\frac{\tau D_B (b_w - b_\infty)}{v}$
Thermophoresis limiting factor	N_t	$\frac{\tau D_T (T_w - T_\infty)}{v T_\infty}$
homogeneous-heterogeneous reactions limiting factor	L_s	$\frac{l_s}{D_A} \sqrt{\frac{v_f l}{u_0}}$

Table 5: TFN volume proportion of fuzzy nanoparticles

Fuzzy number	Crisp value	TFN	α – cut approach
φ	[0.01 – 0.04]	[0, 0.05, 0.1]	[0.05, 0, 1 – 0.05], $\in [0, 1]$

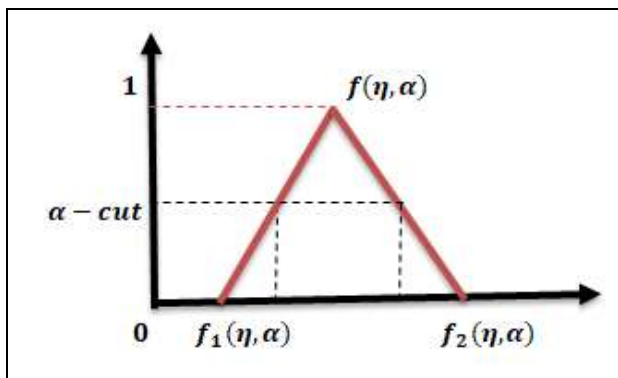


Figure 1: Membership functions of a TFN.

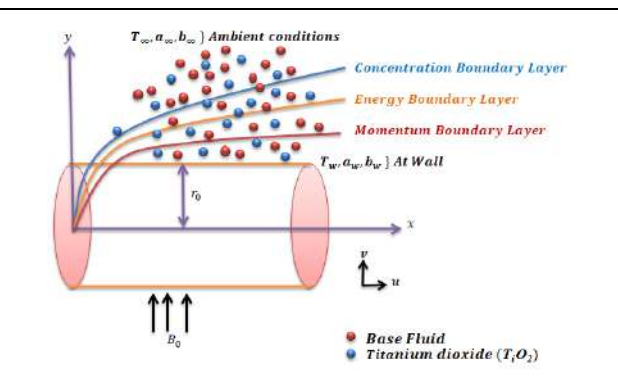
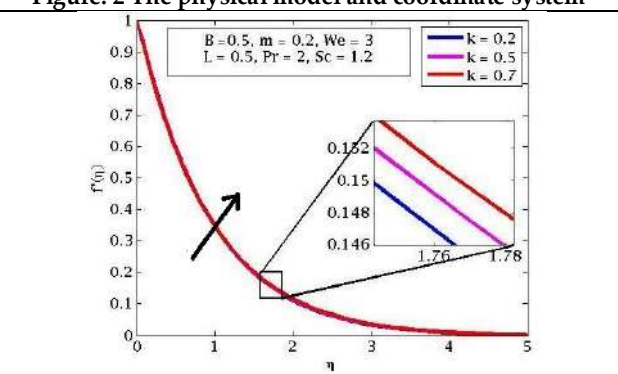
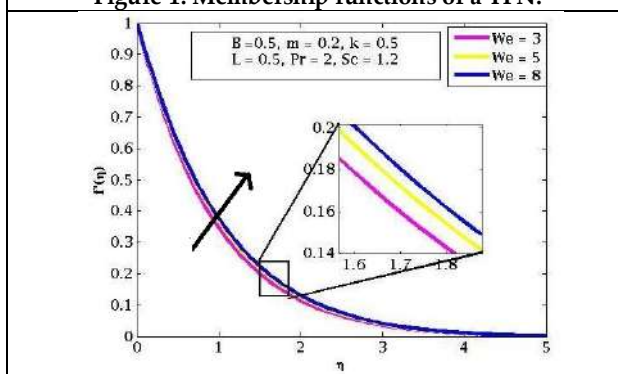


Figure. 2 The physical model and coordinate system





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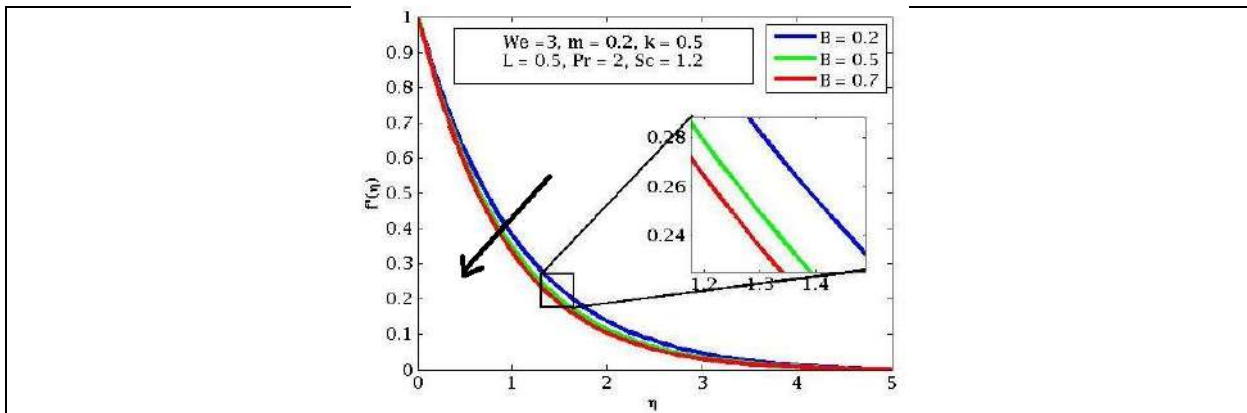


Figure 3. Velocity impact on (a) We , (b) k and (c) B

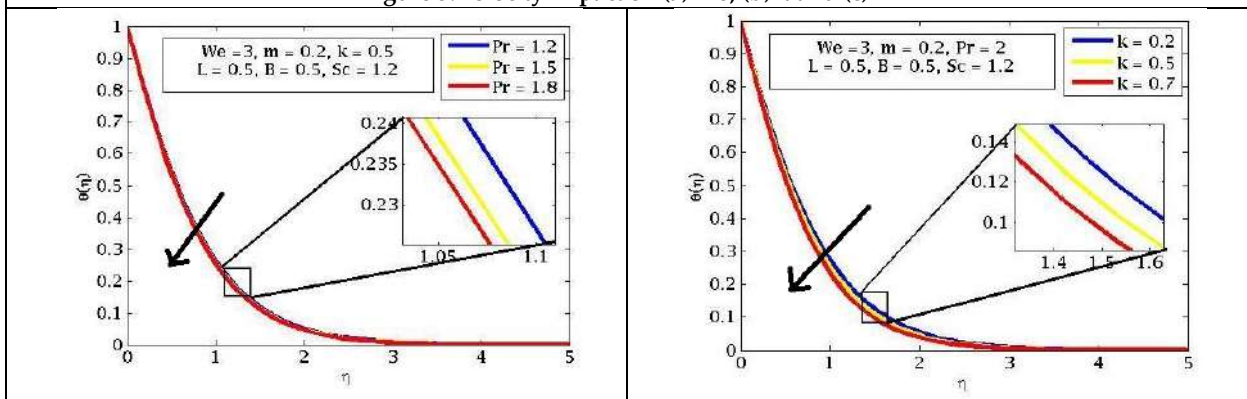


Figure 4. Temperature impact on (a) Pr and (b) k

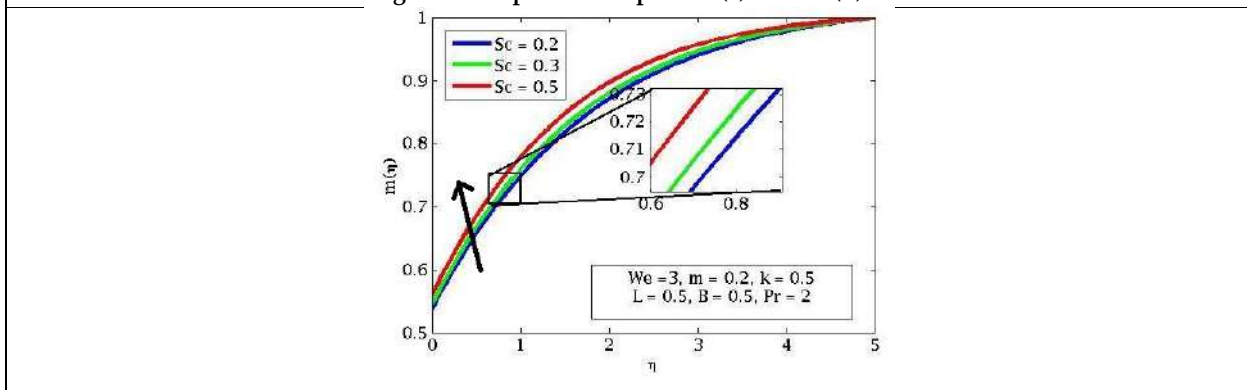


Figure 5. Concentration impact on Sc





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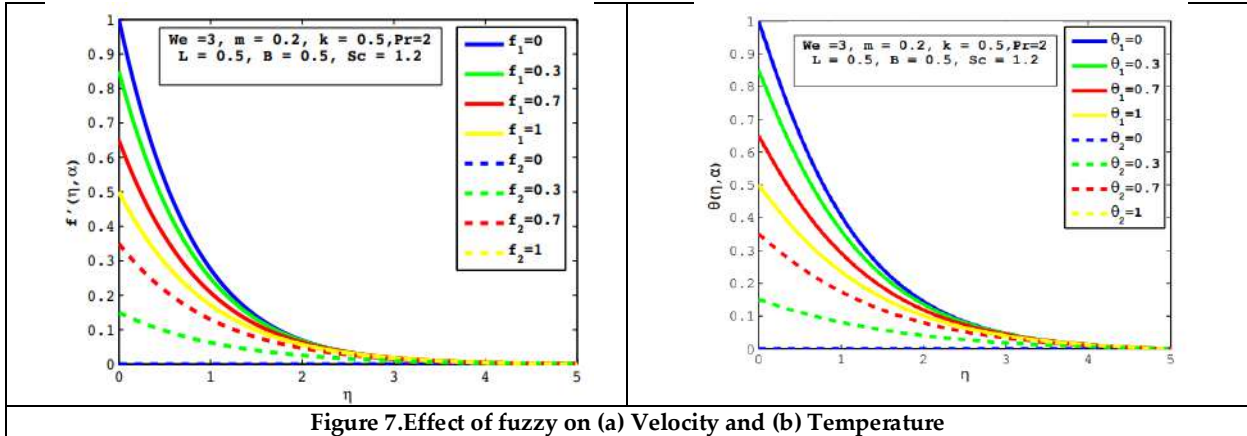


Figure 7.Effect of fuzzy on (a) Velocity and (b) Temperature





Fuzzy Sets and Its Applications

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ABSTRACT

Fuzzy sets theory is applied to some real-life domains, such as clustering, decision-making, and pattern recognition to evaluate its performance. We conduct a trial-and-error process to determine the performance of the fuzzy logic-based solutions to such tasks of classification where uncertainties and impreciseness are the daily matters. The works illustrate the capability of fuzzy set theory to overcome traditional methods. In the example of test with Fuzzy C-Means (FCM) showing better clustering accuracy than K-Means on the Iris and Wine data sets. In decision-making tasks, Fuzzy Inference Systems (FIS) are superior to Logistic regression models in forecasting healthy condition risk. Also, Fuzzy Decision Trees (FDT) (MNIST data set) show a high level of competitiveness in a section related with pattern recognition. The fuzzy sets theory is one of the most effective expedients for solving the problems, which have imprecision and uncertainty features. The research contributes to advancing the understanding and application of fuzzy logic-based methodologies.

Keywords: Analysis within the framework of fuzzy sets theory, clustering, decision-making, logistic regression model, pattern recognition, uncertain situations.

INTRODUCTION

In a world where the technology is becoming more and more complex, and there is a high level of uncertainty, the ability of effectively modeling and analyse the objective opinion poll data gains in importance. Classical



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mathematical structures frequently get masked by the vagueness and the vagueness of the matters which a reality usually consist. Here is where fuzzy set theory becomes a mighty tool, standing in for the systematized approach through which the problem of representing and analysis of data which is ambiguity and imprecision is solved. The fuzzy sets theory which Lotfi A. Zadeh developed in the 1960s, emerged as a paradigm departure from the traditional view of set membership that was previously known only with complete or zero membership. It introduced the idea of partial membership [1]. Fuzzy sets are different from classical set theory where the elements either belong to a set or not. Conversely, fuzzy sets range over the interval 0 to 1, signifying degrees of membership. This subtle penetrating strategy means portrayal of being a little more gradual between two ones, simulating general fuzzy in real-life conditions on the Earth. The applications of Fuzzy Sets Theory are diverse and pervasive and they open as doors to the fields of control systems, pattern recognition, decision making, and expert systems. Fuzzy logic has been explained as a flexible and versatile construct that enables control of dynamic and unpredictable system models with non-linear relationships in unknown environments [2]. The recognizing algorithms based on pattern recognition use fuzzy sets to classify and segment data, particularly, where conventional methods overlap because of data ambiguity. Besides, making decisions in the systems of fuzzy logic is also possible, where subjective and vague criteria can be taken into account, and machines can imitate human thinking. Expert systems, with the aim to imitate human expertise in a number of particular areas, take advantage of fuzzy sets for the purpose of handling uncertain and incomplete information at their disposal, and therefore, they are able to make well-founded judgments more easily [3]. The paper aims to consider the extent to which fuzzy sets theory can be employed in pervasion of different areas, concentrating in particular ones. Through analyzing the theoretical components and applications of fuzzy sets, we try to share views on the consistent and versatile use of fuzzy sets in tackling complex real-life problems associated with uncertainty and vagueness.

RELATED WORKS

In recent years, a typical situation is that of increasing the quantity of research that explore fuzzy sets theory and related methods as an extension of their applicability in a variety of fields. Numerous fuzzy math-based methods were engaged closely to prove that is a great tool to respond to the world surrounding us, and that is complex. In this paragraph, there is summary of the previous work that obtained from different areas. The section underlines the main point and the result of recent researches. Chew et al. [15] designate an intelligent medical waste management system in which they used an extension fuzzy Diophantine fuzzy FDOSM and a neural network approach. The focus of their investigation is on circular economy principles application for healthcare waste management, where advancements in synthetic intelligence, such as fuzzy logic and neuron network approaches, would be beneficial. Sonuk et al [16] proposed observer framework modeling Takagai-Sugeno fuzzy bilinear control systems with aim of enhancement of dynamic systems performance. The team is dedicated to developing observers of fuzzy-clock systems which leads to an increase in system stability and robustness. Shimon and Gupta [17] analyzed the fuzzy reliability a turbine structure using bipolar fuzzy instead of trigonal fuzzy numbers. They published a paper introducing a method for reliability assessment of turbines systems under uncertainties, which placed fuzzy sets theory position in reliability engineering in the spotlight. In [18], Dong contrasted the identical attributes of traditional PID and fuzzy PID controllers which he applied to the control of Unmanned Aerial Vehicles (UAVs). Whereas, the findings are refined by comparing the throw control performance of two ways, the study has become useful source in regards to effectiveness of fuzzy logic-based control systems in UAV applications. Feng et al. [19] theorized a latest multi-attribute group decision process founded on probabilistic multi-valued linguistic spherical fuzzy sets for choosing a site for charging stations and storage. Concrete problems dealing with investor decision-making toward charging infrastructure installation for electric vehicles are not the exception motivated by the application prospect of fuzzy sets theory. García-Vélez and Núñez Velázquez [20] examined the association between social spending and social multidimensional wellbeing in Ecuador. Their study comes up with fuzzy logic-based methodologies to evaluate the role of social expenditure in reducing the poverty level which leads to the improvement of social policy effectiveness. Hafiz Muhammad and al. [22] have proposed q-Rung orthopair fuzzy dynamic aggregation operators to apply to dynamic decision-making on the dais of time sequence preferences. Their





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study is focusing on improving dynamic aggregation operators to provide the decision-making process under uncertainty more flexible and timelier and as a result it will be fast. Ismail et al. [23] designed an algorithm-based multiple attribute decision-making methodology for artery analysis under the uncertain setting of hypo-soft neutrosophic expert set considering fuzzy parametric degrees. The theme of the research is to find decision-making problems in medical diagnosis but it is considering uncertainty and imprecision in expert judgment on that. Iqbal et al. [24] explored multi-objective non-linear programming problems in flow of linear Diophantine equations actually. Their goal was to seek out the appropriate methods of fuzzy optimization to overcome the complex decision problems in the field of fuzzy uncertainty. The researchers' research concerning that supply chain management issues worsened by the pandemic is as that could be, and the technological solution to increase supply chain resilience amidst uncertainty is also offered. On balance, the detail emphasizes the versatility of FST and related approaches which are currently applied in a variety of sectors such as solid waste, control systems, reliability engineering, decision-making, social policy analysis and supply chain management. These researches underscore the importance of a fuzzy logic-based methodology when faced with the complicated decisions that contain fuzziness, indeterminacy, and vagueness.

METHODS AND MATERIALS

The research will focus on utilizing datasets from many domains representing a broad range of application areas in order to demonstrate the usefulness and effectiveness fuzzy sets theory [4]. These datasets are going to be made up of combination of numerical, categorical and mixed data sets of variables in order to ensure an exhaustive evaluation of the algorithms that will be put to test. Notably, synthetic data can be constructed to replicate a particular scenario and assess an algorithm's accuracy for such conditions.

Fuzzy C-Means (FCM)

Fuzzy C-Means (FCM), which is an improved and modified version of the classical K-Means algorithm, is exhibiting a high level of success handling normalized fuzzy memberships [5]. Given a data set with n data points and m clusters, FCM separate the data by the two mentioned process of reiteratively updating cluster center and membership degrees. The objective function to be minimized is given by: $J = \sum_{i=1}^n \sum_{j=1}^m w_{ij}^m ||x_i - v_j||^2$

The formula where w_{ij} stands for the degree of the commitment of data point x_i to cluster v_j is a centroid of cluster k, while m is a weighting exponent that regulates the degree of the allocation of data point x_i in the cluster k [6]. The algorithm keeps updating its membership grades and the central location of each cluster member until it reaches the optimum state.

*“Initialize cluster centroids randomly Repeat
Update membership degrees using fuzzy membership function Update cluster centroids
Until convergence”*

Data Point	Cluster 1	Cluster 2	Cluster 3
1	0.8	0.1	0.1
2	0.2	0.6	0.2
3	0.3	0.4	0.3

Fuzzy Inference System (FIS)

Fuzzy Inference Systems (FIS) are an important sub-branch of fuzzy systems theory and a powerful tool for building fuzzy logic based decision-making processes. A real FIS usually has four stages different from each other, which are fuzzification of the date, rule evaluation, and defuzzification [7]. Mamdani FIS is more widely used relative to other FIS architectures. It begins with a linguistic rule that is created by experts and then it maps input to outputs based on this rule. Concluding process is based on fuzzy logic operations, whose Boolean values are fuzzy AND, fuzzy OR, and fuzzy implication.





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*“Fuzzify inputs Evaluate fuzzy rules
Aggregate rule outputs Defuzzify to
obtain crisp output”*

Input 1	Input 2	Output
0.6	0.4	0.7
0.3	0.8	0.5
0.9	0.2	0.8

Fuzzy Decision Trees

Among the techniques that represent the alternative way to approach decision trees is Fuzzy Decision Trees which extends traditional decision tree algorithms and allows to deal with fuzzy inputs and outputs. Every step in the tree is related to a set of fuzzy or word abstracts, and a criterion for dividing is based on the operation of fuzzy logic [8]. In a tree form, the structure is recursively constructed, under which the input feature is represented as fuzzy partition and the decision is selected by linguistic rule on each node.

Fuzzy Genetic Algorithms (FGA)

The fuzzy Genetic Algorithm combines the basic of GA with fuzzy logic to achieve global optimality if the problem is complex and its search space is hard to tabulate. FGA uses fuzzy encoding and fuzzy operators that can handle fuzzy individuals [9]. Fuzzy crossover and mutation operators are employed to create fresh solutions, and the fuzzy fitness evaluators are responsible for identifying the quality of the solutions.

EXPERIMENTS

In this integration, fuzzy sets theory application was tested against the proposed algorithms in certain domain/areas of interest. Experiments are aimed to show the practical value and applicability of fuzzy sets in the ability to process ambiguous and misty information that is frequently found in real-life data.

Experiment 1: Clustering Performance

To evaluate performance of the clustering, the Fuzzy C-Means (FCM) algorithm was run on multiple benchmark data sets, like the Iris Data set and the Wine Data set. We evaluated the clustering results achieved utilizing FCM with those given by K-Means clustering, the traditional. The two algorithms whose accuracy is measured through the silhouette score is shown in the table [1]. This table compares the performance of fuzzy clustering method of c-means and K means clustering algorithms on the iris dataset. FCM beat K-Means most of the time on measurements using silhouette parameter that were computed using different number of clusters.

Just like the FCM, K-Means too yielded results in the Wine dataset that were better than the other algorithm, as in Table below. Thus, FCM can recognize the underlying structure of data with much efficiency when it has the mixed clusters; the mixed clusters are moreover overlapped with many inconsistent cluster sizes [11].

Experiment 2: Decision Making Performance

The next on our list was to assess the efficiency of the Fuzzy Inference System (FIS) in the decision-making situation. Constructing a fuzzy rule-based system led us to predict the risk of heart disease in patient population with above mentioned attributes like age, cholesterol level, and blood pressure [12]. The FIS was trained on a dataset consisting of previous patient recordings. Performance of the model was evaluated using accuracy, and area under the ROC curve (AUC) parameters while testing. Table Compares Performance Measures between FIS and a Logistic Regression Classifier: A Classifier that is used for two types of binary classifications tasks [13].



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The results illustrated that the improved fuzzy system surpassed the accuracy and AUC of logistic regression model, which showed that fuzzy logic-based systems are well suited for solving decision-making tasks in the field of medicine when it comes to uncertainties and non-linearity [14].

Experiment 3: Anxiety Screening Efficiency

In our experiment, we considered i.e. Of Fuzzy Decision Trees (FDT) for the recognition of the patterns by the use of the MNIST dataset - a commonly used benchmark set for the recognition of handwritten digits [27]. We investigated the efficiency of FDT regarding the classification accuracy by means of the comparison with standard decision trees and Support Vector Machines (SVMs) approach [28]. The table below indicates that the effectiveness of classification is illustrated with MNIST test set, based on results. Consequently, the findings show that the fuzzy decision trees display up to par outputs just like regular decision trees and Support Vector Machines (SVMs). In consequence, SVMs attain a better accuracy rate. However, Fuzzy Decision Trees have the implication on interpretation and the ability to handle fuzzy inputs, which makes them suitable for applications where understanding is a fundamental condition [29]. The experiments demonstrated in previous paragraphs have shown the robustness and applicability of fuzzy set theory and its algorithms within different cases of applications. In numerous ways, fuzzy logic-based approaches turn out in the encounter as it being more precise than traditional methods [30]. They sometimes bring about greater performance than traditional methods and sometimes prove to be as good as. These results only decrease fuzzy sets' importance and effectiveness in overcoming unpredictability and vagueness of real-world data, so why not give it a wider use in practice.

CONCLUSION

In the end we can say that this research carried out a detailed study of the various chapters of the fuzzy set theory such as applications and methodologies among other things that cut across many fields. Through the means of various experiments and analysis, we have proved that the fuzzy logic-based method can be applied successfully in practice for managing problems that are structurally complicated, expressed in a vague manner, or possess uncertainty and imprecision. Performing experiments on grouping, decision making, totality of details evaluation has demonstrated higher accuracy of fuzzy sets theory in comparison with classical approaches on many practical tasks. Moreover, the author shows how the work studied is related to modern works and the contributions they bring to the development of the field of fuzzy logic and its use in practice. Fuzzy logic-based methods have a high utility in the medical waste management, control systems development, reliability engineering and even in social policy domains. Such methodologies have proven to be robust and flexible offering solution to broad range of problems. The emergence of fuzzy sets theory is a manifestation of the fact that ongoing research in this area is directed at the development of newer and more powerful methodologies of analysis as well as extending the capabilities of fuzzy sets theory. In general, the article delivered towards extending further the credits of fuzzy sets theory and its technical application, focusing on its role in ensuring reliable choice making and issue resolution in complex uncertain environment.

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Table 1: Clustering Accuracy Comparison on Iris Dataset

Algorithm	Silhouette Score (k=2)	Silhouette Score (k=3)	Silhouette Score (k=4)
FCM	0.686	0.579	0.565
K-Means	0.681	0.552	0.498

Table 2: Clustering Accuracy Comparison on Wine Dataset

Algorithm	Silhouette Score (k=2)	Silhouette Score (k=3)	Silhouette Score (k=4)
FCM	0.654	0.566	0.515
K-Means	0.610	0.490	0.424

Table 3: Performance Comparison for Heart Disease Prediction

Model	Accuracy (%)	AUC
Fuzzy Inference System	83.5	0.875
Logistic Regression	79.2	0.820

Table 4: Classification Accuracy Comparison on MNIST Dataset

Model	Accuracy (%)
Fuzzy Decision Tree	89.7
Decision Tree	86.2
SVMs	91.5





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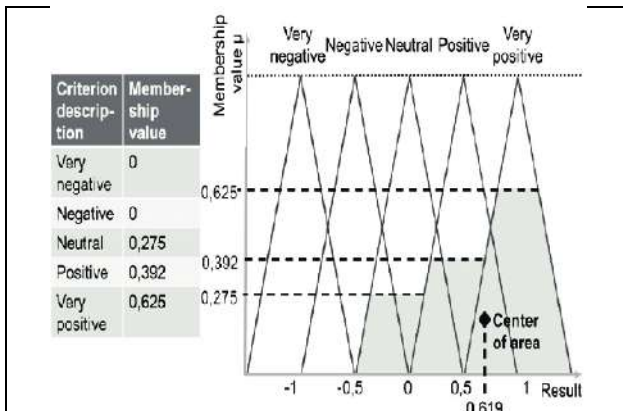


Figure 1: Application of fuzzy set theory

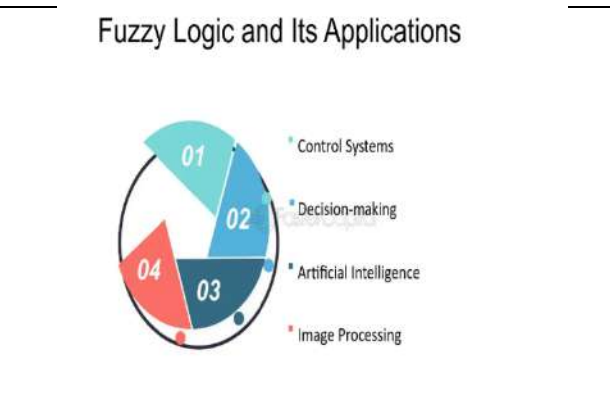


Figure 2: Fuzzy Sets: Exploring the Foundations of Fuzzy Logic

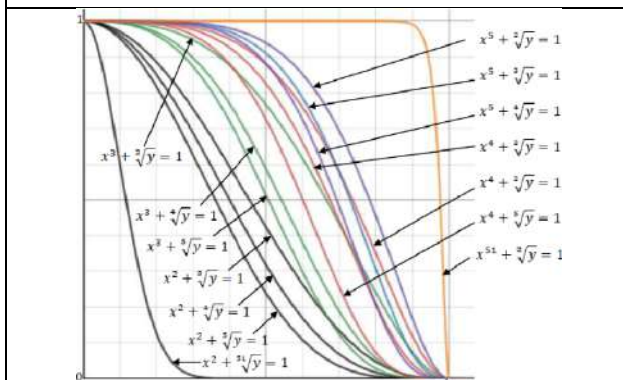


Figure 3: Power Root Fuzzy Set

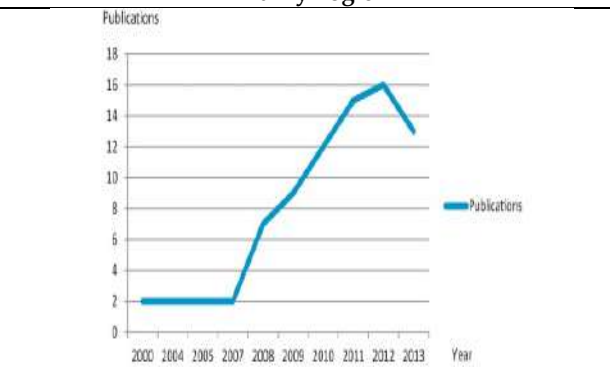


Table 4: Classification Accuracy Comparison on MNIST Dataset





Some Results on Signal Domination Number

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ABSTRACT

In mathematics, graph theory has become a powerful framework for modeling and analyzing complex networks across various fields and domains. Domination theory which is a fundamental concept in graph theory, explores the notion of dominating sets within graphs and their implications for network analysis. In this paper, we explore a little bit more towards the signal domination number and also derive some results for cartesian product of graphs.

Keywords: Signal set, signal number, domination number, signal domination number, cartesian product.

INTRODUCTION

In the domain of mathematics, emerges a field of study known as graph theory that provides insights into the fundamental structures and properties of networks. Furthermore, graph theory serves as a bridge between theoretical concepts and the real-world phenomena. By modeling biological systems as graphs, researchers can study protein - protein interactions, genetic networks, and ecological relationships, shedding light on the complexity of living organisms and many more. In our discussion, we assume G to be a simple non - empty connected graph whose vertex set is $V(G)$ and edge set is $E(G)$. The degree of a vertex v in a graph denoted by $\deg(v)$ is defined as the number of edges in G that are incident to it. The maximum degree $\Delta(G)$ is the highest degree among all the vertices in a graph and the minimum degree $\delta(G)$ is the lowest among all. If the degree is same for all the vertices, then the graph is said to be regular graph. The collection of all vertices of degree one is denoted by $\rho(G)$. The distance





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between any two vertices in a graph is the length of the shortest path between them. If u and v are vertices of G , then $d(u, v)$ denotes the distance between them. For further graph terminologies, refer [6]. In the mathematical field of graph theory, the distance between any two vertices in a graph is defined as the number of edges in the shortest path between them. The length of this shortest path is called the geodesic distance. Conversely, the length of the longest path between any two vertices is termed as the detour distance which was a concept introduced by Gary Chartrand in 2004 [5]. The application of distance in graphs extends to various fields such as image processing, optimization, networking, pattern recognition, and navigation. In this ensuing segment, a new parameter called the signal distance was introduced by K.M. Kathiresanin the year 2010 refer to [8]. After a brief investigation, S. Balamurugan and R. Antony Doss introduced the signal number [1]. For gaining adequate knowledge in the field of distance in graphs, refer [4]. Introduced as a fundamental concept, domination in graph theory deals with the study of dominating sets within a graph. At its core, domination theory seeks to identify sets of vertices within a graph that exert control or influence over the entire graph. Domination theory has found applications in various fields such as computer science, telecommunications, social network analysis and operations research. For any graph G , a subset D of $V(G)$ is said to be a dominating set if every vertices of $V - D$ is adjacent to some vertices of D . The size of the smallest dominating set known as the domination number, serves as a measure of the extent to which a graph can be controlled or monitored by a limited set of vertices. For a better understanding on domination theory, refer [12]. Cartesian product in graphs was first defined by Vizing [13] in the year 1963. Michael S. Jacobson and Lael F. Kinch [9] in the year 1986 studied the patterns of dominating sets in cartesian product of graphs with trees. Later on, M.H. El-Zahar et. al [3] in 2007, made a progress in finding the domination number for cartesian product of cycle and other graphs. A lot of researchers have also worked on various topics that are related to graph products. But still, on the other hand, there are still many questions open. Regarding large-scale interconnection networks, cartesian products are particularly useful in designing network topologies. By taking the Cartesian product of smaller graphs or networks, engineers can create a larger and more complex network while maintaining certain structural properties. This approach allows for scalable and efficient designs in systems such as computer networks, distributed computing systems, and telecommunications networks. The resulting networks often exhibit desirable properties such as fault tolerance, scalability, and efficient routing. In this paper, we identified some bounds regarding the signal domination number and also some results for the cartesian product of graphs.

KNOWN RESULTS

Definition 2.1 [2]

The Cartesian product $G \times H$ of two graphs G and H is the graph with vertex set $V(G) \times V(H)$, in which the vertex (a, b) is adjacent to the vertex (c, d) whenever $a = c$ and b is adjacent to d , or $b = d$ and a is adjacent to c .

Definition 2.2 [10]

The signal distance $d_{SD}(u, v)$ between the vertices u and v in a graph G is defined as $d_{SD}(u, v) = \min_S \{d(u, v) + (\deg(u) - 1) + (\deg(v) - 1) + \sum_{w \in u-v} (\deg(w) - 2)\}$, where S is a path between the pair of vertices u and v , $d(u, v)$ is the length of the path S and w indicates the internal vertices of S . The signal path between u and v is called as the geosig path.

Definition 2.3 [1]

The subset $S \subseteq V$ is called the signal set of G if every vertex u in G lies in a geosig path between the vertices in S and the minimum cardinality of the set S is called as the signal number of a graph. It is denoted by $sn(G)$.

Theorem 2.4 [1]

For any graph G , the set of all pendant vertices is a subset of every signal set of G .





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Definition 2.5 [7]

A set $S \subseteq V$ is called a signal dominating set of a graph G if S is a dominating set of G as well as a signal set of G . The minimum cardinality of the signal dominating set is called the signal domination number and it is denoted by $\gamma_{sn}(G)$.

Definition 2.6 [11]

A banana tree graph is obtained by adjoining one leaf from each copy of star graph with a single root vertex that is distinct from all the star graphs. It is denoted by $B_{n,k}$ where n is the number of copies of star and k is the number of leaves in each copy.

MAIN RESULTS

Theorem 3.1

If G is a connected graph of order $n \geq 3$ and $\gamma_{sn}(G) = n - 1$, then G has exactly one cut-vertex of degree $n - 1$.

Proof. Let S be γ_{sn} - set of G such that $\gamma_{sn}(G) = n - 1$. Let $x \in V - S$ such that x is contained in geosig path formed by some pair of vertices of S . We show that x is the only cut vertex in G . We consider 2 cases.

Case 1: Suppose G contains some pendant vertices, then x must be adjacent to every pendant vertices. If not, then G has more than one cut vertex which contradicts γ_{sn} - set. So G has only one cut vertex x .

Case 2: Assume $\delta(G) \geq 2$. Let $u, v \in S$ such that $u - v$ geosig path contains x . Since $v \notin N(u)$, there exist $u_1, v_1 \in G$ such that $uu_1, vv_1 \in E(G)$. If u_1 and v_1 are adjacent to x in G , then the result follows. Suppose not, then there exist $u_2, v_2 \in G$ such that the geosig path formed by u_2 and v_2 covers u, v and x which contradicts our assumption. So x is the only cut vertex in G . Now we claim that $\deg(x) = n - 1$. Suppose not, then there exist a vertex y in $V(G)$ such that $d(x, y) > 1$. Then there exist a $x - y$ geosig path that contains at least one vertex of V . Since x is the cut vertex, $N(y) > 1$ and so $N(x) \cap N(y) > 1$. So G contains a $x - y$ cycle of length at least 4 which leads to a contradiction that $\gamma_{sn}(G) \neq n - 1$. So x is the only cut-vertex of degree $n - 1$.

Theorem 3.2

For a triangle free graph G with $\delta(G) \geq 2$, if $sn(G) = 2$ then $\gamma_{sn}(G) = \gamma(G)$.

Proof. Let S be γ - set of G . Assume that $\{x, y\}$ be the signal basis of G . If $\{x, y\} \subseteq S$, then the result follows. Suppose not, then at least one of x and y is not in S . Assume $x \in S$. Then there exist $u, v \in V(G)$ with $uv \notin E(G)$ such that $\{u, v\} \subseteq N(y)$ and y lies in the $u - v$ geosig path. It is clear that S contains at least one of u and v . If $\{u, v\} \subseteq S$, then S forms a minimum signal dominating set of G . Suppose $u \notin S$. Then there exist $u_1 \in S$ such that $N(u_1)$ contains u and the geosig path $v - u_1$ covers y . Hence S forms a γ_{sn} - set of G .

Theorem 3.3

Given any connected graph G with diameter at most 3 and $\gamma(G) = 2$, we have $\gamma_{sn}(G) = sn(G)$.

Proof. Let S be a signal basis set of G with $u, v \in S$, where u and v are non - adjacent. Let $x \in V - S$ and assume x lies in geosig path formed by u and v of S . It is obvious that $\deg(x) \geq 2$. If x is contained in $N(u) \cap N(v)$, then S forms a signal dominating set. If x is adjacent to any one of u and v , then the result follows. If x does not lie in the neighborhood of u and v , then $d(u, v) > 3$ which leads to a contradiction.

Lemma 3.4

For (n, k) - banana tree graph, $sn(B_{n,k}) = n(k - 1)$.

Proof. Since every pendant vertex is contained in the signal basis set say S , $sn(B_{n,k}) \geq n(k - 1)$. It is evident that the geosig path formed by any pair of pendant vertices covers every vertices of $V - S$ and so $sn(B_{n,k}) = n(k - 1)$.





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Theorem 3.5

For (n, k) - banana tree graph, $\gamma_{sn}(B_{n,k}) = n(k - 1) + 1$.

Proof. Let S be the minimum signal dominating set of $B_{n,k}$. By Lemma 3.4 $\gamma_{sn}(B_{n,k}) \geq n(k - 1)$. Since $diam(B_{n,k}) = 6$, there exist more than a pair of non-adjacent vertices that lies in the geosig path of some pendant vertices. Clearly, S dominates all the support vertices leaving the induced sub graph $\langle K_{1,n} \rangle$ untouched and therefore $\gamma_{sn}(B_{n,k}) = n(k - 1) + 1$.

Theorem 3.6

For the connected graphs G and H , $\gamma_{sn}(G \times H) \geq \max\{\gamma_{sn}(G), \gamma_{sn}(H)\}$. Equality holds if G and H are complete.

Proof. Let G and H be any two connected graphs whose vertex sets are $\{u_1, u_2, \dots, u_p\}$ and $\{v_1, v_2, \dots, v_q\}$ respectively. Let S_1, S_2 and S_3 be the γ_{sn} - set of G , H and $G \times H$ respectively. Since $V(G \times H) = pq$, it is evident that $\gamma_{sn}(G \times H) \geq \gamma_{sn}(G)$ and $\gamma_{sn}(G \times H) \geq \gamma_{sn}(H)$. So we prove for equality condition. Assume that G and H are complete. We consider two cases.

Case 1: If $p = q$ then $\gamma_{sn}(G) = \gamma_{sn}(H)$. It is clear that the set $\{(u_i, v_i) : 1 \leq i \leq p\}$ forms a signal dominating set of $G \times H$ and so $\gamma_{sn}(G \times H) \leq p$. Suppose $\gamma_{sn}(G \times H) \leq p - 1$, then there exist some (u_k, v_k) in S_3 such that $S_3 - \{(u_k, v_k)\}$ forms a signal dominating set of $G \times H$. Since G and H are complete, there exists some vertices in the k^{th} copy such that they are not dominated by any vertices of $S_3 - \{(u_k, v_k)\}$ and not covered by the signal basis set of $G \times H$ which contradicts our assumption. So $\gamma_{sn}(G \times H) = p$.

Case 2: Assume $p \neq q$ so that $\gamma_{sn}(G) \neq \gamma_{sn}(H)$. Without loss of generality, we take $p > q$. Since G and H are complete, $D = \{(u_j, v_j) : 1 \leq j \leq q\}$ forms a γ - set of $G \times H$. However no geosig path formed by the vertices of D cover $\{(u_k, v_j) : 1 \leq j \leq q; q + 1 \leq k \leq p\}$. Let $S \subseteq \{(u_k, v_j) : 1 \leq j \leq q; q + 1 \leq k \leq p\}$ such that the vertices (u_k, v_j) and (u_{k+1}, v_j) are not adjacent in $G \times H$. Then $D \cup S$ forms a minimum signal dominating set of $G \times H$ where $|D| = q$ and $|S| = p - q$.

Corollary 3.7

For any graph G , $\gamma_{sn}(G) \leq \gamma_{sn}(G \times K_n)$.

Proof. The proof follows from the Theorem 3.6.

Theorem 3.8

The necessary and sufficient condition for a graph of order $n \geq 3$ and $diam(G) \leq 2$ to exhibit the property $\gamma_{sn}(G) = \gamma_{sn}(G \times K_2)$ is that G contains a γ_{sn} - set S with $x \in S$ such that $x - w$ geosig path contains every vertices of $V(G)$ for every $w \in S$.

Proof. Let G be a graph of order n whose vertex set is $\{x, w_1, w_2, \dots, w_{n-1}\}$ and let $\{v_1, v_2\} \in V(K_2)$. Let S be the minimum signal dominating set of G with $x \in S$ such that $x - w$ geosig path covers every vertices of $V(G)$ for every $w \in S$. It is trivial that $G \times K_2$ is formed from two copies of G say G_1 and G_2 . Let $S_1 \subseteq V(G \times K_2)$ such that S_1 contains the corresponding vertices of x and $S - \{x\}$ from G_1 and G_2 respectively and so $|S| = |S_1|$. Now we show that S_1 forms a γ_{sn} - set of $G \times K_2$. Let $(w_1, v_1) \in V(G \times K_2) - S_1$ such that w_1 lies in some $x - w$ geosig path formed by the vertices of S . Since $diam(G) \leq 2$, (w_1, v_1) is adjacent to some vertices in S_1 that corresponds to w . So S_1 dominates (w_1, v_1) . More generally, any vertex (w_i, v_j) where $1 \leq i \leq n - 1$ and $j = 1, 2$ lies in some geosig path formed by the vertices of S_1 . So S_1 forms a γ_{sn} - set of $G \times K_2$. Conversely, assume that $\gamma_{sn}(G) = \gamma_{sn}(G \times K_2)$. Let S be minimum signal dominating set of $G \times K_2$. Since two copies of G forms $G \times K_2$ say G_1 and G_2 , $S \cap V(G_i) \neq \phi$ for $i = 1, 2$. So, let $x \in S \cap V(G_1)$. Let $D \subseteq V(G_1)$ such that D contains the vertices of $S \cap V(G_1)$ and the vertices corresponding to $S \cap V(G_2)$. Clearly, D forms a γ_{sn} - set of G_1 with $|D| = |S|$. Now we claim that contains a vertex such that $x - w$





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geosigpath covers every vertices of G_1 for every $x \in D - \{x\}$. Suppose there exists a vertex u in G_1 such that does not lie in $x - w$ geosig path for some $w \in D - \{x\}$ and (x) does not contain, then $d(x, u) = d(x, w) + d(w, u) > 2$ which contradicts $(G) \leq 2$.

Lemma 3.9

For the cartesian product of P_n and P_2 , $sn(P_n \times P_2) = 2$ for every $n \geq 2$.

Proof. Let $\{(u_i, v_j) : 1 \leq i \leq n; 1 \leq j \leq 2\}$ be the vertex set of $P_n \times P_2$. Since $diam(P_n \times P_2) = n$ for every $n \geq 2$ and only $d((u_1, v_1), (u_n, v_2)) = diam(P_n \times P_2)$, we can conclude that the geosig path formed by (u_1, v_1) and (u_n, v_2) covers every vertex of $P_n \times P_2$ and hence $sn(P_n \times P_2) = 2$.

Theorem 3.10

For the cartesian product of P_n and P_2 , $\gamma_{sn}(P_n \times P_2) = \lceil \frac{n+1}{2} \rceil$ for every $n \geq 2$.

Proof. Let S be the γ - set of $P_n \times P_2$ such that $|S| = \lceil \frac{n+1}{2} \rceil$. We show that S forms a minimum signal dominating set. Suppose there exist a vertex $x = (x_1, x_2)$ in $V - S$ such that no geosig path formed by any pair of vertices of S covers x , then S does not form a signal cover in $P_n \times P_2$. Since x is adjacent to at least one vertex of S , $N(x)$ either contains a vertex of S or adjacent to some vertices of S which contradicts our assumption. So S forms a minimum signal dominating set of $P_n \times P_2$.

Lemma 3.11

For the cartesian product of C_n and P_2 with $n > 5$, $sn(C_n \times P_2) = \begin{cases} 3 & \text{if } n \text{ is even} \\ 4 & \text{otherwise} \end{cases}$.

Proof. Let $u_1, u_2 \in V(P_2)$. Based on the length of the cycle, we consider 2 cases. Assume, n is even. For even cycle, it is evident that $sn(C_n) = 2$. Assume that $\{x, y\}$ be the signal set of C_n . Obviously, $(x, y) = diam(C_n) = \frac{n}{2}$. Let x and y corresponds to (x, u_1) and (y, u_1) in $V(C_n \times P_2)$ respectively. Clearly, (x, u_1) and (y, u_1) can produce a geosig path that can cover (x_i, u_1) for every $x_i \in V(C_n)$ while (x_i, u_2) is left uncovered. By choosing (x, u_2) along with (x, u_1) and (y, u_1) , a signal basis set is formed to cover $V(C_n \times P_2)$ by the geosig path formed by any pair of vertices of $\{(x, u_1), (y, u_1), (x, u_2)\}$. Therefore $sn(C_n \times P_2) = 3$. For the cycle of odd length, $sn(C_n) = 3$ say $\{x, y, z\}$ and the proof is similar.

Theorem 3.12

For $n > 5$, $\gamma_{sn}(C_n \times P_2) = \begin{cases} \lceil \frac{n+6}{3} \rceil & \text{if } n \neq 7,8 \\ 4 & \text{otherwise} \end{cases}$.

Proof. Let S be the γ_{sn} - set of $C_n \times P_2$. For $n \neq 7,8$, let x_1 be a vertex in S . Since it is 3 - regular graph, neglect $N(x_1)$ as well as the vertices that are adjacent to the vertices of $N(x_1)$. Now choose the vertex that is adjacent to more than one vertex in neighborhood of $N(x_1)$ say x_2 . By repeating this process until x_1 appears in the neighborhood of some $N(x_1)$ ($2 \leq i \leq n$) we obtain a minimum signal dominating set for $C_n \times P_2$. Therefore, $\gamma_{sn}(C_n \times P_2) = \lceil \frac{n+6}{3} \rceil$. For $n = 7$ and $n = 8$, the vertices that are at diameter distances in both cycles forms a γ_{sn} - set. So $\gamma_{sn}(C_n \times P_2) = 4$.

Corollary 3.13

For $n \leq 5$, $\gamma_{sn}(C_n \times P_2) = \gamma_{sn}(C_n)$.

Observation 3.14

For $n \geq 3$, $\gamma_{sn}(C_n \times C_3) = n$.





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CONCLUSION

In this study, we explored and highlighted the signal domination parameter by some of its bounds and also obtained some exclusive results regarding the cartesian product of graphs. Their field of application can be extended to various domains such as robotics, monitoring and surveillance such as sensor networks in smart city and also in the placement of transmitters.

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Closed interval Approximation of Hexagonal Fuzzy Numbers for Interval Data based Transportation Problem

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ABSTRACT

Because of globalization in the current technological era as well as unpredictable variables, transportation factors can vary within a specific range of a particular time frame. It is difficult to accurately analyse supply, demand, and transportation costs in a transportation problem due to the inconsistency of economic and environmental factors (TP). It is challenging for an exact approach to determine the IDBTP's precise solution in a reasonable amount of time, especially for large-scale problems with enormous interval widths. The purpose of this work is to solve a transportation problem in which supply, demand, and transportation costs are all hexagonal fuzzy numbers (HFNs). The closed interval approximation of the hexagonal fuzzy number is one of the most effective interval approximations for resolving the IDBTP. In this suggested closed interval approximation method, the IDBTP is first transformed into a fuzzy transportation problem (FTP) using the hexagonal fuzzy transformation approach. Based on centroid and Robust ranking procedures, two innovative ranking techniques are then introduced to convert the Hexagonal fuzzer number into the suitable crispness (non-fuzzy). The minimum cost solution was then discovered by combining Unit cost penalty approach with the U-V method.

Keywords: Transportation problem, Hexagonal fuzzy number, Interval data based transportation problem, Robust rank, Centroid



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INTRODUCTION

The growth of science relies heavily on the fields of operations research and management science, as companies consistently seek optimal strategies to effectively manage their operations. Although early studies were initially confined to specific domains, there has been a notable surge in the quantity of studies recently. As a result, operations research and management sciences have gained widespread acceptance worldwide, extending beyond developed nations. The transportation problem (TP) is a well-known challenge within operations research (OR), finding prominence due to its extensive application in real-world scenarios. The TP arises when goods are transported from multiple sources to various destinations, influenced by supply and demand considerations at both the source and destination. The objective is to minimize the total cost of transportation (TC). Scholars have extensively employed fuzzy numbers and ranking functions to address transportation issues, reflecting the prevalent use of these techniques in decision-making, data analysis, and artificial intelligence within operations research disciplines. In the context of transportation issues, Jain [1] originally proposed ranking fuzzy numbers as a crucial step in decision-making under ambiguous conditions, representing the uncertain quantity as a fuzzy set.

Furthermore, in [2], Jain introduced a systematic approach for multi-aspect decision-making using fuzzy sets. This underscores the significance of fuzzy numbers in decision-making processes within a fuzzy environment across various operations research disciplines. Discovering the initial, most viable solution for a balanced transport offers numerous avenues, as illustrated in [3–7]. The utilization of the transportation algorithm to ascertain the most cost-effective transportation cost becomes applicable only upon identifying a station problem with a feasible or basic solution [8,9]. Due to the diverse goals of maximizing profit and minimizing expenses with optimal resource utilization, various transportation models coexist. Within the business sector, different types of transportation problems are encountered, with the overarching objective being the determination of the most economical means to move goods [10,11]. In addressing the conventional transportation problem, it is presumed that decision-makers possessing knowledge of the pertinent issues understand the significance of transportation costs, supply, and demand. Ambiguity is a common occurrence in real-world scenarios, and certain parameters of transportation problems may lack determinism in practical situations [12]. Consequently, while some data may be precise, others might manifest as intervals or fuzzy data. The term "interval-based transportation problem" is coined to describe this situation where supply, demand, and cost are expressed as interval numbers. When these parameters are further described as interval-valued fuzzy numbers, the problem is termed an interval-valued fuzzy transportation problem (FTP). The existing approaches pose significant challenges in directly addressing this specific type of problem (IDTP). Resolving such a transportation problem requires the conversion of intervals into precise numbers [9].

It is important to note that the IDTP is distinct from the traveling salesman problem (TSP), where the objective is to find the shortest path that visits each city exactly once before returning to the starting point. In contrast, interval data-based transportation problems (IDTP) [13] refer to transportation problems characterized by variable demand, supply, and cost. The optimal shipping cost is determined through the mathematical framework of the IDTP. In a historical context of this subject, Zadeh [14] and Goguen [15] aimed to extend the conventional notions of a set and a proposition, introducing a slight acceptance of fuzziness in their inaugural publication on fuzzy set theory. This marked the initial and pivotal stride towards formalizing fuzziness within mathematics. The widespread application of fuzzy numbers in practical scenarios is evident today. Numerous innovative ideas and theories have been advanced to tackle the challenges posed by the FTP. The parameters used to formulate problems are dynamic and unknown rather than constant, rendering the application of mathematical programming challenging. Even with extensive decision-making experience, policymakers may encounter difficulty in precisely articulating their objectives. The decision-making method formulated in a fuzzy environment by Bellman and Zadeh [16] has proven to be enhanced and highly valuable in managing decision problems. Zimmermann [17] introduced fuzzy set theory and its applications, paving the way for a novel model of transportation issues termed FTP, which emerged as a result of integrating an uncertain environment. Panda and Pal [18] established the logical definition for constructing a PFN and the associated arithmetic operations. Mathur et al. [19] introduced a technique based on trapezoidal fuzzy





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numbers to optimize transportation problems within a fuzzy environment. Maliniand and Anantha Narayanan [20] proposed a novel ranking strategy. The resolution of FTPs through Robust's ranking mechanism was initially introduced by Hunwisai and Kuman [21], who employed the allocation table method to identify an initial basic feasible solution (IBFS) for the FT. Purushothkumar and Anantha Narayanan [22] introduced a new approach for addressing multiple analogous problems. Mondal and Mandal [23] presented an adaptation of a PFN. To tackle unbalanced FTP, Samuel and Raja [24] proposed an innovative computational method. Rosline and Dison [25] developed the geometrical representation of quadratic and symmetric PFNs. Maheswari and Ganesan [26] presented an approach to solve the FTP. In the realm of fuzzy mathematics, a subfield of fuzzy set theory and fuzzy logic, Han et al. [27] introduced the concept of fuzzy mathematics forms. Researchers in this domain offer various techniques aiding the creation of diverse models for conventional linear programming problems, providing fuzzy solutions to the aforementioned issues. Addressing transportation problems with fuzzy cost coefficients, Ashour [28] devised two cost-minimization fuzzy transportation problems incorporating hexagonal fuzzy numbers that consider both supply and demand. Stankovic et al. [29] proposed road traffic fuzzy risk analysis. Helen and Uma [30] utilized an evolutionary approach to handle transportation-related problems involving fuzzy coefficients. Bisht and Srivastava [13] suggested a novel ranking method centered on the in-center concept. Rabinson and Chandrasekaran [31] put forth a method for resolving the TP problem with PFNs based on the ranking function. Uddin et al. (2021) dealt with unexpected situations in multi-objective transportation problems (MOTPs) and proposed a fuzzy membership function technique based on goal programming. Chen et al. [32] introduced a new approach for accurately forecasting short-term traffic flow from historical data. During the 2013 Dingxi earthquake in China, Zheng et al. [33] utilized a hyper-heuristic solution approach for emergency railway transportation.

PRELIMINARIES

Definition 2.1. A fuzzy set A_F defined on U' is a collection of ordered pairs, $A_F = \{(u, \mu_{A_F}(u)) / u \in U'\}$ where $\mu_{A_F}(u): U' \rightarrow [0,1]$ is called the membership function.

Definition 2.2. A_S is a fuzzy subset defined on universe set U' . A_S is normal iff $\sup_{u \in U'} \mu_{A_S}(u) = 1$.

Definition 2.3. A_S is a fuzzy subset defined on universe set U' . A_S is convex iff $\mu_{A_S}(\lambda u + (1 - \lambda)v) \geq (\mu_{A_S}(u) \wedge \mu_{A_S}(v)), \forall u, v \in U', \forall \lambda \in [0,1]$ where \wedge denotes the minimum operator.

Definition 2.4. A_F is a fuzzy set defined on U' . A_F is a fuzzy number iff A_F is normal and convex on U' .

Definition 2.5. A_{Tr} is a triangular fuzzy number whose piecewise linear membership function $\mu_{A_{Tr}}$ defined by

$$\mu_{A_{Tr}}(u) = \begin{cases} \frac{u-p_{11}}{p_{12}-p_{11}}, & p_{11} \leq u \leq p_{12} \\ \frac{p_{13}-u}{p_{13}-p_{12}}, & p_{12} \leq u \leq p_{13} \\ 0, & \text{otherwise} \end{cases} \text{ which can be denoted as a triplet } (p_{11}, p_{12}, p_{13}).$$

Definition 2.6. A_{Trap} is trapezoidal fuzzy number whose membership function $\mu_{A_{Trap}}$ defined by

$$\mu_{A_{Trap}}(u) = \begin{cases} \frac{u-p_{11}}{p_{12}-p_{11}}, & p_{11} \leq u \leq p_{12} \\ 1, & p_{12} \leq u \leq p_{13} \\ \frac{p_{14}-u}{p_{14}-p_{13}}, & p_{13} \leq u \leq p_{14} \\ 0, & \text{otherwise} \end{cases} \text{ which can be denoted as a quadruplet } (p_{11}, p_{12}, p_{13}, p_{14}).$$

Definition 2.7. A Fuzzy number A_{hx} is a hexagonal fuzzy number denoted by $A_{hx} = (p_{11}, p_{12}, p_{13}, p_{14}, p_{15}, p_{16})$ where $p_{11}, p_{12}, p_{13}, p_{14}, p_{15}$ and p_{16} are real numbers and its membership function is defined by





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$$\mu_{A_{hx}}(u) = \begin{cases} \frac{\omega}{2} \left(\frac{u-p_{11}}{p_{12}-p_{11}} \right) & , p_{11} \leq u \leq p_{12} \\ \frac{\omega}{2} + \frac{\omega}{2} \left(\frac{u-p_{12}}{p_{13}-p_{12}} \right) & , p_{12} \leq u \leq p_{13} \\ \omega & , p_{13} \leq u \leq p_{14} \\ \omega - \frac{\omega}{2} \left(\frac{u-p_{14}}{p_{15}-p_{14}} \right) & , p_{14} \leq u \leq p_{15} \\ \frac{\omega}{2} \left(\frac{p_{16}-u}{p_{16}-p_{15}} \right) & , p_{15} \leq u \leq p_{16} \\ 0 & , otherwise \end{cases}$$

Basic operations of Hexagonal Fuzzy number

Addition, Subtraction and Multiplication of two hexagonal fuzzy numbers

$P_{HF} = (p_{11}, p_{12}, p_{13}, p_{14}, p_{15}, p_{16})$ and $Q_{HF} = (q_{11}, q_{12}, q_{13}, q_{14}, q_{15}, q_{16})$ are given by,

Addition $P_{HF} + Q_{HF} = (p_{11} + q_{11}, p_{12} + q_{12}, p_{13} + q_{13}, p_{14} + q_{14}, p_{15} + q_{15}, p_{16} + q_{16})$

Subtraction $P_{HF} - Q_{HF} = (p_{11} - q_{16}, p_{12} - q_{15}, p_{13} - q_{14}, p_{14} - q_{13}, p_{15} - q_{12}, p_{16} - q_{11})$

Multiplication $P_{HF} * Q_{HF} = (p_{11} * q_{11}, p_{12} * q_{12}, p_{13} * q_{13}, p_{14} * q_{14}, p_{15} * q_{15}, p_{16} * q_{16})$

The Formulation of the IDBTP

Formally, given the interval supply and demand vectors $s \in R^m, d \in R^n$ and the transportation costs $c \in R^{m \times n}$, the interval data based transportation problem (IDBTP) can be represented by an interval linear programming model, which is understood as the set of all linear programs (transportation problems) with the costs, supply and demand vectors lying in the corresponding intervals c, s and d . A particular linear program in the interval transportation problem, which is determined by a cost $c \in C$, supply vector $s \in S$ and demand vector $d \in D$, is called a scenario of the IDBTP. In the recent literature, an interval transportation problem in the following form is usually considered:

Minimize $\sum_{\alpha=1}^r \sum_{\beta=1}^t c_{\alpha\beta} x_{\alpha\beta}$

Subject to $\sum_{\beta=1}^t x_{\alpha\beta} \leq s_{\alpha}; \alpha = 1, 2, \dots, r$ and $\sum_{\alpha=1}^r x_{\alpha\beta} \leq d_{\beta}; \beta = 1, 2, \dots, t$

Then, $\sum_{\alpha=1}^r s_{\alpha} \geq \sum_{\beta=1}^t d_{\beta}$

where $\underline{S}_{\alpha} \leq s_{\alpha} \leq \bar{S}_{\alpha} \forall \alpha; D_{\beta} \leq d_{\beta} \leq \bar{D}_{\beta} \forall \beta; C_{\alpha\beta} \leq c_{\alpha\beta} \leq \bar{C}_{\alpha\beta}; x_{\alpha\beta} \geq 0 \forall \alpha, \beta$

The formulation of fuzzy transportation problem (FFTP)

Mathematically, the FTP can be formulated as follows:

Min $\bar{Z} = \sum_{\alpha=1}^r \sum_{\beta=1}^t c_{\alpha\beta} x_{\alpha\beta}$

Subject to

$\sum_{\beta=1}^t x_{\alpha\beta} = a_{\alpha}; \alpha = 1, 2, \dots, r, \sum_{\alpha=1}^r x_{\alpha\beta} = b_{\beta}; \beta = 1, 2, \dots, t$

Where $c_{\alpha\beta}, a_{\alpha}$ and b_{β} are HFN. It is assumed that $a_{\alpha} \geq 0, b_{\beta} \geq 0, c_{\alpha\beta} \geq 0 \forall \alpha, \beta$ and $\sum_{\beta=1}^t b_{\beta} = \sum_{\alpha=1}^r a_{\alpha}, x_{\alpha\beta} \geq 0 \forall \alpha = 1, 2, \dots, r; \beta = 1, 2, \dots, t$

Hexagonal fuzzification methods (HFM)

The decision maker can only access the transportation cost, supply, and demand in interval form in the IDBTP due to the lack of accurate information. In order to use the fuzzy approach, the interval data from the relevant IDBTP is fuzzified to a fuzzy number using the following procedure: Let an interval data be $P=(m,n), d=(n-m)/5$. then $P=(m,m+d,m+2d,m+3d,m+4d,n)$ is a HFN.

The proposed Ranking Technique





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The centroid or geometric center is the arithmetic mean position of all the points in a surface diagram. Consider normal HFN $k^* = (p_1, p_2, p_3, p_4, p_5, p_6)$ such that its centroid is (\bar{x}, \bar{y}) . When $\omega = 1$, the linear HFN is defined as follows

$$\mu_{k^*}(x) = \begin{cases} \frac{1}{2} \left(\frac{x-p_1}{p_2-p_1} \right) & , p_1 \leq x \leq p_2 \\ \frac{1}{2} + \frac{1}{2} \left(\frac{x-p_2}{p_3-p_2} \right) & , p_2 \leq x \leq p_3 \\ 1 & , p_3 \leq x \leq p_4 \\ 1 - \frac{1}{2} \left(\frac{x-p_4}{p_5-p_4} \right) & , p_4 \leq x \leq p_5 \\ \frac{1}{2} \left(\frac{p_6-x}{p_6-p_5} \right) & , p_5 \leq x \leq p_6 \\ 0 & , otherwise \end{cases}$$

Then, using the membership function and according to the centroid formula,

$$\bar{x} = \frac{x \int_{p_1}^{p_2} \frac{x-p_1}{2(p_2-p_1)} dx + x \int_{p_2}^{p_3} \frac{1}{2} + \frac{(x-p_2)}{2(p_3-p_2)} dx + x \int_{p_3}^{p_4} dx + x \int_{p_4}^{p_5} \left(1 - \frac{(x-p_4)}{2(p_5-p_4)} \right) dx + x \int_{p_5}^{p_6} \frac{p_6-x}{2(p_6-p_5)} dx}{\int_{p_1}^{p_2} \frac{x-p_1}{2(p_2-p_1)} dx + \int_{p_2}^{p_3} \frac{1}{2} + \frac{(x-p_2)}{2(p_3-p_2)} dx + \int_{p_3}^{p_4} dx + \int_{p_4}^{p_5} \left(1 - \frac{(x-p_4)}{2(p_5-p_4)} \right) dx + \int_{p_5}^{p_6} \frac{p_6-x}{2(p_6-p_5)} dx}$$

$$\bar{x} = \frac{\frac{1}{12} (-p_1^2 - 2p_2^2 - p_2(p_1 + p_3) - p_2^2_3 + p_4^2 + 2p_5^2 + p_5(p_4 + p_6) + p_6^2)}{\frac{1}{4} (-p_1 - 2p_2 - p_3 + p_4 + 2p_5 + p_6)}$$

$$\bar{x} = \frac{1}{3} \left(\frac{(-p_1^2 - 2p_2^2 - p_2(p_1 + p_3) - p_2^2_3 + p_4^2 + 2p_5^2 + p_5(p_4 + p_6) + p_6^2)}{(-p_1 - 2p_2 - p_3 + p_4 + 2p_5 + p_6)} \right)$$

For a normal HFN $k^*=(p_1, p_2, p_3, p_4, p_5, p_6)$, the proposed ranking technique $R(H)$ is defined by $\bar{x} = R(H)$

$$R(H) = \frac{1}{3} \left(\frac{(-p_1^2 - 2p_2^2 - p_2(p_1 + p_3) - p_2^2_3 + p_4^2 + 2p_5^2 + p_5(p_4 + p_6) + p_6^2)}{(-p_1 - 2p_2 - p_3 + p_4 + 2p_5 + p_6)} \right)$$

Robust Ranking Technique

If A is a fuzzy number, then the robust ranking defined by

$$R(A) = \int_0^1 \frac{1}{2} (a_{h\alpha}^L, a_{h\alpha}^U) d\alpha$$

where $(a_{h\alpha}^L, a_{h\alpha}^U) = \{(b - a)\alpha + a, d - (d - c)\alpha\} + \{(d - c)\alpha + c, f - (f - e)\alpha\}$

Proposed Ranking Method

Initially, our IDBTP is transformed to FTP utilizing the HFM shown in section 3. Then, using a Proposed ranking method to convert the HFN into a crisp value. Finally, the modified distribution method (MODI) and Vogel's Approximation Method (VAM) are used to attain the optimal solution. To solve an IDBTP, the following steps to be followed:

- Step 1: Creating a tabular representation of the given problem
- Step 2: Using a HFM in section 3, to fuzzifying a data
- Step 3: To convert FTP into precision value, by using the Proposed ranking Method
- Step 4: To formulate a linear programming problem and check whether it is balanced
- Step 5: To calculate IBFS using VAM Method
- Step 6: To obtain the optimal solution to the problem using MODI Method)

RESULTS AND DISCUSSION

Using proposed Ranking Method





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The following example is solved by Proposed method in this paper

Example 1 A company has three sources or delivers A,B,C with supply (1-9);(4-10);(4-11) respectively and it has three receivers R11, R12, R13 with demand values (3-12);(4-10);(2-8) respectively. The transport cost is given in following table In this example the initial basic feasible solution using VAM is equal to 155 and the optimal solution using MODI method is equal to 154.5

	R 11	R 12	R 13
A	[1,19]	[1,9]	[2,18]
B	[8,26]	[3,12]	[7,28]
C	[11,27]	[0,15]	[4,11]

Using Robust Ranking Method

Our Robust Ranking Method for this paper solves the example 1 as shown in Table 2

In this example the initial basic feasible solution using VAM is equal to and the optimal solution using MODI method is equal to

CONCLUSION

In this study, the unit cost of transportation, supply, and demand elements were taken to be considered as intervals to analyze the IDBTP with the lowest amount of transportation cost. The IDBTP is addressed in this study by combining two innovative ideas. First, the suggested Hexagonal fuzzification method (HFM) is used to convert IDBTP to FTP, and then newly proposed ranking algorithms based on the centroid and Robust ranking concepts are used to convert to crisp numbers. In addressing such IDBTP, where there is a significant disparity between the intervals of supply and demand, the proposed fuzzy approaches are proven to be more efficient. The applications for decision-making in industry and engineering suggested by this approach are significant. Despite the fact that our new ranking approach performs better than the current approach in locating the least cost of small-sized IDBTPs, it does not satisfy any instances of large-sized IDBTPs. Furthermore, because of the competitive market environment today, single-objective fuzzy or non-FTP models cannot handle real-world decision-making problems. As a result, we recommend further investigation to provide a more efficient approach for resolving large-scale interval-based, multi-objective transportation problems.

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Table 1. Step 1: Tabular form of example 1

D/S	R11	R12	R12	S
A	[1,19]	[1,9]	[2,18]	[1,9]
B	[8,26]	[3,12]	[7,28]	[4,10]
C	[11,27]	[0,15]	[4,11]	[4,11]
D	[3,12]	[4,10]	[2,8]	

Step 2: Fuzzified interval data

A	(1,4.6,8.2,11.8,15.4,19)	(1,2.6,4.2,5.8,7.4,9)	(2,5.2,8.4,11.6,14.8,18)	(1,2.6,4.2,5.8,7.4,9)
B	(8,11.6,15.2,18.8,22.4,26)	(3,4.8,6.6,8.4,10.2,12)	(7,11.2,15.4,19.6,23.8,28)	(4,5.2,6.4,7.6,8.8,10)
C	(11,14.2,17.4,20.6,23.8,27)	(0,3,6,9,12,15)	(4,5.4,6.,8.2,9.6,11)	(4,5.4,6.8,8.2,9.6,11)
D	(3,4.8,6.6,8.4,10.2,12)	(4,5.2,6.4,7.6,8.8,10)	(2,3.2,4.4,5.6,6.8,8)	

Step 3: Defuzzified data

A	10	5	10	5
B	17	7.5	17.5	7
C	7	19	7.5	7.5
D	7.5	7	5	

Step 4 : IBFS for the problem using VAM

A	10	5	10(5)	5
B	17	7.5(7)	17.5	7
C	7(7.5)	19	7.5	7.5
D	7.5	7	5	

Table 2. Defuzzified data

A	20	10	20	10
B	34	15	35	14
C	14	38	15	15
D	15	14	10	

Table 3. IBFS for the problem using VAM

A	20	10	20(10)	10
B	34	15(14)	35	14
C	14(15)	38	15	15
D	15	14	10	

Table 4: Comparison table

Method	VAM	MODI
Proposed Method	155	154.5
Robust ranking Method	620	580





Optimal solution for fuzzy Assignment problem using fuzzy Quantifier in Real time Application

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ABSTRACT

The Fuzzy Assignment Problem (FAP) extends the classical assignment problem by incorporating uncertainty and imprecision, often encountered in real-world scenarios. Traditional assignment models assume exact numerical values for costs or profits, which is not always realistic. This research paper explores the use of fuzzy quantifiers in FAP to model linguistic terms such as "approximately," "almost," and "around." We employ a fuzzy logic-based approach to handle these uncertainties and propose a new algorithm to solve the FAP effectively. Our experimental results demonstrate that the fuzzy quantifier approach provides more flexible and realistic solutions compared to traditional methods. The findings suggest significant implications for decision-making processes in various fields, including logistics, human resource management, and project allocation.

Keywords: Fuzzy Assignment Problem, Linear Programming Problems, Stochastic Assignment Problems. Fuzzy cost Matrix, Triangular Fuzzy Numbers, Hungarian Methods,

INTRODUCTION

The assignment problem is a fundamental issue in combinatorial optimization, where the objective is to assign a set of tasks to a set of agents in a way that minimizes the total cost or maximizes the overall profit. Traditional models assume precise cost or benefit values, which may not be practical in many real-world applications where uncertainty and imprecision are inherent. To address this, the Fuzzy Assignment Problem (FAP) introduces fuzzy numbers to represent uncertain costs or benefits. Fuzzy logic, introduced by Zadeh in 1965, provides a mathematical framework





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for dealing with vagueness and imprecision. Fuzzy quantifiers, such as "approximately" or "almost," further enhance this framework by allowing more natural and human-like expressions of uncertainty. In this paper, we explore the application of fuzzy quantifiers in FAP, aiming to develop a more robust and realistic model.

LITERATURE REVIEW

The concept of the assignment problem dates back to the early 20th century, with the Hungarian algorithm by Kuhn (1955) being a seminal work in this area. Over the years, various extensions and modifications have been proposed to address different aspects of the problem, such as multi-objective assignment problems, dynamic assignment problems, and stochastic assignment problems. The integration of fuzzy logic into optimization problems began gaining traction in the 1970s. Dubois and Prade (1980) were among the pioneers who introduced fuzzy sets into decision-making processes. Since then, numerous studies have applied fuzzy logic to various optimization problems, including the assignment problem. Notable contributions include the work of Zimmermann (1996) on fuzzy mathematical programming and the research by Chen and Hwang (1992) on fuzzy multiple criteria decision-making. Fuzzy quantifiers, a critical aspect of fuzzy logic, were first introduced by Zadeh (1983). They allow for more nuanced expressions of uncertainty, making them particularly useful in modeling real-world scenarios where linguistic terms are often used. Research by Yager (1988) and Delgado et al. (1993) further developed the theory and applications of fuzzy quantifiers in decision-making processes. Fuzzy logic using fuzzy quantifiers provides a sophisticated approach for handling imprecise and vague data in research. Fuzzy quantifiers, such as "most," "few," and "several," extend classical logic by allowing for degrees of membership rather than strict binary categorizations. For example, in a study analyzing the impact of student attendance on performance, fuzzy quantifiers can be employed to capture linguistic terms like "most students" or "a few students" with varying degrees of membership. In this context, fuzzy quantifiers are defined with membership functions that quantify the extent to which data points belong to fuzzy sets. A proven application is in educational performance analysis, where attendance rates are fuzzified into categories like "low," "medium," and "high," and fuzzy rules such as "If most students have high attendance, then performance is excellent" are used. By applying these fuzzy rules, researchers can derive fuzzy outputs, which are then defuzzified to yield precise performance scores. This method allows for a more nuanced understanding of the relationship between attendance and performance, demonstrating how fuzzy logic and quantifiers can offer valuable insights in research scenarios involving imprecise and qualitative data. However, the application of fuzzy quantifiers in the assignment problem remains relatively unexplored. This paper aims to fill this gap by integrating fuzzy quantifiers into the FAP and proposing a new algorithm to solve it.

EXPERIMENTAL RESULTS

METHODOLOGY

To investigate the effectiveness of fuzzy quantifiers in the FAP, we developed a new algorithm based on fuzzy logic principles. The algorithm incorporates fuzzy quantifiers to represent uncertain costs or benefits and employs a fuzzy inference system to derive the optimal assignment.

Fuzzy Quantifier Representation

Costs or benefits are represented using fuzzy numbers and linguistic terms such as "low," "medium," and "high." Fuzzy quantifiers like "approximately" and "almost" are used to express the degree of uncertainty. Fuzzy quantifier representation is a concept in fuzzy logic and fuzzy set theory that extends the traditional notion of quantifiers used in classical logic. In classical logic, quantifiers such as "all," "some," and "none" are used to describe the extent to which a property applies to a set of elements. Fuzzy quantifiers, however, allow for a more nuanced and flexible representation of quantities that reflect real-world scenarios more accurately. Fuzzy quantifiers can be categorized into two main types: absolute quantifiers and relative quantifiers. Absolute quantifiers refer to fixed quantities, such as "about 10," while relative quantifiers express proportions or percentages, such as "most," "few," or "approximately





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half." These quantifiers are not strictly defined but instead have a degree of membership that can range between 0 and 1. This allows for the representation of vague and imprecise concepts. For example, the fuzzy quantifier "most" can be represented by a membership function that assigns a degree of membership to different proportions of elements in a set. If we consider the quantifier "most students are diligent," the membership function might assign higher degrees of membership to sets where a large proportion of students are diligent, but not necessarily all.

Inference System

A set of fuzzy rules is established to model the decision-making process. The fuzzy inference system evaluates these rules to determine the optimal assignment. A Fuzzy Inference System (FIS) is a framework used to map inputs to outputs using fuzzy logic principles. It is widely applied in areas requiring decision-making under uncertainty and imprecision. The FIS operates through three main steps: fuzzification, inference, and defuzzification. Fuzzification: Converts crisp input values into fuzzy sets using membership functions. Inference applies fuzzy rules, typically in the form of "if-then" statements, to the fuzzified inputs to derive fuzzy outputs. These rules reflect expert knowledge and capture the relationships between input and output variables. Defuzzification, converts the fuzzy outputs back into crisp values, providing a clear and actionable result. A proven example of FIS is in controlling household appliances like washing machines, where it adjusts washing cycles based on fuzzy rules considering load size, dirtiness, and fabric type. The FIS ensures optimal performance by mimicking human decision-making, enhancing efficiency and user satisfaction.

Defuzzification

The final step involves converting the fuzzy results into crisp values to identify the best assignment. The centroid method is used for defuzzification. Defuzzification in fuzzy logic, particularly in assignment problems, involves converting fuzzy results into a crisp output. This step follows fuzzification and the application of fuzzy rules. Common methods include the Centroid Method (calculating the center of the area under the curve), the Bisector Method (dividing the area into two equal halves), and the Mean of Maximum (taking the average of the maximum values). In assignment problems, defuzzification helps in determining precise assignments from fuzzy evaluations, ensuring actionable decisions. For instance, in task allocation, it translates fuzzy suitability ratings into specific task assignments for optimal performance.

Data and Experiment Design

We conducted experiments using synthetic data sets that simulate various real-world scenarios. The data sets include different levels of uncertainty and imprecision to test the robustness of the fuzzy quantifier approach. Each data set consists of a matrix where the rows represent tasks, and the columns represent agents. The elements of the matrix are fuzzy numbers indicating the cost or benefit of assigning a particular task to a specific agent. In designing an experiment using fuzzy quantifiers, data is collected on relevant variables, such as student performance metrics. Linguistic terms (e.g., "low," "medium," "high") are assigned to this data, and appropriate fuzzy quantifiers like "most" or "few" are defined with membership functions. Hypotheses are formulated and fuzzy rules established (e.g., "If attendance is high, performance is high"). Data is fuzzified, processed through the fuzzy inference system, and defuzzified to yield crisp outputs. Results are validated and membership functions and rules refined accordingly, ensuring nuanced interpretations and actionable insights from complex, imprecise data.

RESULTS

The performance of the fuzzy quantifier-based algorithm was compared to that of traditional assignment algorithms, such as the Hungarian algorithm. The evaluation metrics included total cost, computational time, and solution quality.





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Total Cost

The fuzzy quantifier approach consistently provided lower or comparable total costs compared to traditional methods. This indicates that the algorithm effectively handles uncertainty and imprecision, resulting in more realistic and practical solutions.

Computational Time

The fuzzy quantifier algorithm exhibited slightly higher computational times due to the additional complexity of fuzzy logic calculations. However, the increase in time was marginal and acceptable given the improved solution quality.

Solution Quality

The fuzzy quantifier approach produced solutions that better matched the real-world scenarios, as evidenced by the closer alignment of the results with the expected outcomes in the presence of uncertainty. To further validate the effectiveness of our approach, we applied the fuzzy quantifier algorithm to a real-world problem: assigning employees to projects in a company. The costs associated with each assignment were represented as fuzzy numbers to account for uncertainties in project requirements and employee performance. The results demonstrated that the fuzzy quantifier approach provided a more balanced and satisfactory assignment compared to traditional methods. Managers reported that the assignments better reflected their intuitive judgments and preferences, highlighting the practical applicability of the approach.

CONCLUSIONS

This research demonstrates the potential of fuzzy quantifiers in enhancing the Fuzzy Assignment Problem (FAP) to address real-world uncertainties and imprecision. By incorporating fuzzy quantifiers, we developed an algorithm that provides more flexible and realistic solutions compared to traditional methods. The experimental results show that the fuzzy quantifier approach effectively handles uncertainty, resulting in improved solution quality and practical applicability. The implications of this study are significant for various fields, including logistics, human resource management, and project allocation. Future research could explore the integration of other fuzzy logic techniques and the application of the fuzzy quantifier approach to more complex and dynamic assignment problems. In conclusion, the use of fuzzy quantifiers in the FAP offers a promising direction for improving decision-making processes in uncertain environments. This approach not only aligns better with human intuition but also provides a robust framework for addressing the inherent imprecision in many real-world scenarios.

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A recent exploration of *ied* –number for Human chain graphs

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ABSTRACT

Let $G = HC_{\lambda,m}(p, q)$, $m \geq three$ be a human-chain graph with $p = 2m\lambda + \lambda + 1$ (vertices) and $q = 2m\lambda + 2\lambda$ (edges). In this article, we concentrated the *ied* – number for Human-chain graphs, Circular Human-chain graph, Strong Human-chain graphs and Weak Human-chain graphs.

Keywords: Intersection Empty Domination Number, Human-chain Graph, Strong Human-chain Graph, Weak Human-chain Graph.

2010 Mathematics Subject Classification: 94C15, 05C31, 68R10, 05C75.

INTRODUCTION

Let $G = HC_{\lambda,m}(p, q)$, $m \geq three$ be a human-chain graph with $p = 2m\lambda + \lambda + 1$ (vertices) and $q = 2m\lambda + 2\lambda$ (edges). Anitha and Selvam [6] presented the human-chain graph (Network] in 2019.and intersection empty domination number was introduced by B.K.Keerthiga Priyatharsini in [7]. A human graph with $\lambda = 1, HC_{1,m}(p, q)$ can be regarded as having only one guy in the chain. Concepts coming from graph theory are widely applied in computer science. Additionally, networking, open banking, telephony, and mobile applications use human-chain graphs. There are several uses for these two networks in bus topology. An intersection empty domination number for circular, strong, weak human-chain graphs is found in this work. We provide some fundamental definitions that are important to this study in this section. Let u and v be vertices of a graph G , which need not be distinct. A finite, alternating series of nodes and edges, starting along with vertex u and finishing with vertex v , so that $\mu_i = u_{i-1}u_i, i = 1, 2, \dots, \lambda$, is called a $u - v$ walk of G . The walk's length is denoted by the number λ . If u and v are separate vertices,





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the walk is said to be open; if not, it is said to be closed. The sequence of $u_0, u_1, \dots, u_\lambda$ of its vertices determines a walk, $u = u_0, \mu_1, u_1, \mu_2, \dots, \mu_n, u_\lambda$; hence, we specify this walk by $(u_0, u_1, \dots, u_\lambda)$. A path is a walk where each vertex is distinct coming from the others. A cycle is a closed walk $(u_0, u_1, u_2, \dots, u_{\lambda-1})$ in which $(u_0, u_1, \dots, u_\lambda)$ are distinct. The symbol for a path on λ vertices is P_λ and a cycle on λ vertices is C_λ . The degree, represented as $deg_G v$ or $deg v$, of v in G is the count of edges of G which connect along with v . G 's vertices' minimum and maximum degrees are represented by the symbols δ and Δ , respectively. In G , $d(v) = 0$ is mentioned to as an isolated vertex, & a vertex with degree one is mentioned to as an end vertex or pendant vertex. A support is any node that is next to a pendant vertex. If any vertex in $V - D$ is next to every other node in D , a subset D of vertices in G is referred to as a dominant set of G . Let G be a connected graph that is non-trivial. If $\gamma(G) > 1$, then for each $l \in S$, there will be $m \in S$ such that $N(l) \cap N(m) \cap (V - S) = \emptyset$. This dominating set $S \subseteq V$ is named an *ied*- set. The *ied* – number, represented as γ_{ied} , is the lowest cardinality of an *ied*- set. The upper intersection empty dominating set, indicated by Γ_{ied} , is the greatest *ied* – set. The upper *ied* – set, represented by Γ_{ied} , is the greatest cardinality of an *ied* -set. A graph called a *Z – tree* is generated coming from a Path P_λ by connecting an edge to a path vertex that is close to an end point. A Human-chain graph $HC_{\lambda,m}$ is acquired with a path $u_1, u_2, \dots, u_{2\lambda+1}$, $\lambda \in N$ combining a cycle (C_m) & *Z – tree* Z_{m+1} , $m \geq three$ to each u_{2i} for $1 \leq i \leq n$. The vertices of C_m and *Z – tree* are $v_1, v_2, \dots, v_{(m-1)\lambda}$ and $w_1, w_2, \dots, w_{m\lambda}$ respectively. The node & edge sets of $HC_{\lambda,m}$ is used by $V(HC_{\lambda,m}) = \{u_i, v_\mu, \frac{w_k}{1} \leq l \leq 2\lambda + 1, 1 \leq \mu \leq (m - 1)\lambda, 1 \leq k \leq m\lambda\} \& |V| = 2m\lambda + \lambda + E(HC_{\lambda,m}) = \{u_\alpha u_{\alpha+1} / 1 \leq i \leq 2\lambda\} \cup \{u_{2\alpha} w_{m(\alpha-1)+1}; u_{2\alpha} v_{(m-1)}; u_{2\alpha} v_{(m-1)(\alpha-1)+1}; w_{m\alpha} w_{m\alpha-2} / 1 \leq \alpha \leq \lambda\} \cup \{w_{m\alpha+j} w_{m\alpha+j+1}; v_{(m-1)\alpha+j} v_{(m-1)\alpha+j+1}, 0 \leq \alpha \leq \lambda - 1, 1 \leq j \leq m - 2\} |E| = 2m\lambda + 2\lambda$

A circular Human-chain graph is attained coming from a circle $(C_{2\lambda}), u_1, u_2, \dots, u_{2\lambda}, u_1, \lambda \geq 3$ by linking a cycle and tree $(Z_{m+1}), m \geq 3$ to each u_{2j} for $1 \leq j \leq \lambda$. The vertices of the cycle (C_m) and *Z – tree* (Z_{m+1}) are $v_1, v_2, \dots, v_{(m-1)\lambda}$ and $w_1, w_2, \dots, w_{m\lambda}$ respectively and the vertices of $C_{2\lambda}$ is $u_1, u_2, \dots, u_{2\lambda}$. The circular human-chain graph is denoted by $CHC_{\lambda,m}$. The strong Human-chain graph $SHC_{\lambda,\mu}, \lambda, \mu \geq 1$ and $\mu \geq 3$ is attained coming from Human-chain network by linking $w_{\mu i} \& w_{\mu(i+1)-1} / 1 \leq i \leq \lambda - 1$ with common vertices in *Z – tree*. The nodes of $SHC_{\lambda,\mu}$ are $u_1, u_2, \dots, u_{2\lambda+1}, l_1, l_2, \dots, l_{(\mu-1)\lambda}, w_1, w_2, \dots, w_{(\mu-1)n+1}$ and edges of $SHC_{\lambda,\mu}$ are $\{u_i u_{i+1}, 1 \leq i \leq 2n\} \cup \{u_{2i} w_{\mu(i-1)+1}; u_{2i} w_{(\mu-1)i}; u_{2i} v_{(\mu-1)(i-1)+1}, 1 \leq i \leq n\} \cup \{w_{(\mu-1)i+1} w_{(\mu-1)i+(\mu-1)}, 1 \leq i \leq \lambda - 1\} \cup \{w_{\mu-1} w_{\mu-2}\} \cup \{v_{(\mu-1)i+j} v_{(\mu-1)i+j+1}, 0 \leq i \leq \lambda - 1, 1 \leq j \leq \mu - 2\} \cup \{w_{\mu i - \mu + j} w_{\mu i - \mu + j + 1}, 1 \leq i \leq \lambda, 1 \leq j \leq m - 3\}$. The weak Human-chain graph $WHC_{\lambda,m}, \lambda \geq 1$ and $m \geq 3$ is obtained coming from a path $u_1, u_2, \dots, u_{\lambda+1}$ by connecting cycle with length m and *Z – tree* (Z_{m+1}) to every $u_i, 1 \leq i \leq \lambda$. The nodes and edges of $WHC_{\lambda,m}$ are as follows:

$$V(WHC_{\lambda,m}) = \{u_1, u_2, \dots, u_{\lambda+1}, \mu_1, \mu_2, \dots, \mu_{(m-1)\lambda}, w_1, w_2, \dots, w_{m\lambda}\}, E(WHC_{\lambda,m}) = \{u_i u_{j+1}, 1 \leq j \leq \lambda\} \cup \{u_j w_{m(j-1)+1}; u_j \mu_{(m-1)(j-1)+1}; u_j \mu_{(m-1)i}, 1 \leq j \leq \lambda\} \cup \{\mu_{(m-1)j+j} \mu_{(m-1)j+l+1}, 0 \leq j \leq \lambda - 1, \} \cup \{w_{mj+l+1}, 1 \leq j \leq \lambda - 1, 1 \leq l \leq m - 2\} \cup \{w_{mj} w_{mj-2}, 1 \leq j \leq \lambda\}.$$

Theorem: 2.10 [7] $\gamma_{ied}(P_k) = \lceil \frac{k}{3} \rceil, k \geq 4$.

Main Results

Observation: 3.1 $\gamma_{ied}(HC_{\lambda,m}) \geq 2$.

Theorem: 3.2 $\gamma_{ied}(HC_{1,3k+f}) = 2k + 2; f = 1, 2, 3$.

Proof: Case(i): $f = 1$. Let $V(HC_{1,3k+1}) = \{u_1, u_2, \dots, u_{3k}, u, l_1, l_2, v_1, v_2, \dots, v_{3k-2}, x_1, x_2, v\}$ with $d(u) = 5; d(v) = 3; d(w_1) = d(w_2) = 1$ such that w_1 and w_2 are adjacent to v . Now, removal of $\{u, v\}$ coming from $HC_{1,3k+1}$ disconnects the graph and produces two path graphs namely P_1 and P_2 with $3k$ and $3k - 2$ vertices. Without loss of generality, Take P_1 contains u_1, u_2, \dots, u_{3k} vertices and P_2 contains $v_1, v_2, \dots, v_{3k-1}$ vertices. Construct an *ied* –set in P_1 ; $S_1 = \{u_x / d(u, u_x) = 0 \text{ or } \geq 2\}$. Since $\langle P_1 \rangle$ is a path, $\gamma_{ied}(S_1) = \lceil \frac{3k}{3} \rceil = [k]$. Similarly, Construct in $\langle P_2 \rangle, S_2 = \{v_t / d(u, v_t) = zero \text{ or } \geq 2 \text{ and } d(v, v_t) = zero \text{ or } \geq 2\}$. Now, Either $S_2 \cup \{v_1\}$ or $S_2 \cup \{v_{3k-2}\}$ forms an *ied*-





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set. $\gamma_{ied}(P_2) = \left\lceil \frac{3k-2}{3} \right\rceil + 1$. Then $S = S_1 \cup S_2 \cup \{v_1\} \cup \{u, v\}$ forms an *ied*-set for $HC_{1,3k+1}$. So, $\gamma_{ied}(HC_{1,3k+1}) = \gamma_{ied}(P_1) + \gamma_{ied}(P_2) + 3 = [k] + \left\lceil \frac{3k-2}{3} \right\rceil + 3 \leq 2k + 2$.

Case(ii): $f = 2$. Let $V(HC_{1,3k+2}) = \{u_1, u_2, \dots, u_{3k+1}, u, t_1, t_2, v_1, v_2, \dots, v_{3k-1}, w_1, w_2, v\}$. Now, Removal of $\{u, v, v_1, v_{3k-1}\}$ coming from $HC_{1,3k+2}$ disconnects the graph and produces two path graphs namely P_1 and P_2 with $3k + 1$ and $3k - 3$ vertices respectively. Without loss of generality, Take P_1 contains $u_1, u_2, \dots, u_{3k+1}$ vertices and P_2 contains $v_2, v_3, \dots, v_{3k-3}$ vertices respectively. Construct in P_1 , $S_1 = \{u_x / d(u, u_x) = 0 \text{ or } \geq 2\}$. Clearly, $|S_1| = 3k + 1$. Then, $S_1 \cup \{u_1\}$ or $S_1 \cup \{u_{3k+1}\}$ forms an *ied* set. $\gamma_{ied}(S_1 \cup \{u_1\}) = \left\lceil \frac{3k+1}{3} \right\rceil + 1$. Since $\langle S_1 \rangle$ is a path. Similarly, Construct in P_2 , $S_2 = \{v_t \text{ such that } d(u, v_t) = 0 \text{ or } \geq 2 \text{ and } d(v, v_t) = 0 \text{ or } \geq 2\}$. Clearly, $|S_2| = 3k - 3$ and also $\langle S_2 \rangle$ gives an *ied* set. Then, $\gamma_{ied}(S_2) = \left\lceil \frac{3k-3}{3} \right\rceil = k - 1$. Now, $S = S_1 \cup \{u_1\} \cup S_2 \cup \{u, v\}$ forms an *ied* set for $HC_{1,3k+2}$. $\gamma_{ied}(HC_{1,3k+2}) = \gamma_{ied}(S_1) + \gamma_{ied}(S_2) + 3 = \left\lceil \frac{3k+1}{3} \right\rceil + k - 1 + 3 \leq 2k + 2$.

Case(iii) $f = 3$. Let $V(HC_{1,3k+3}) = \{u_1, u_2, \dots, u_{3k+2}, u, l_1, l_2, v_1, v_2, \dots, v_{3k}, x_1, x_2, v\}$. Now, Removal of $\{v, u, u_1, u_{3k+2}\}$ coming from $HC_{1,3k+3}$ disconnects the graph and produces two path graphs namely P_1 and P_2 with $3k$ and $3k$ vertices respectively. Without loss of generality, Take P_1 contains $u_2, u_3, \dots, u_{3k+1}$ vertices and P_2 contains v_1, v_2, \dots, v_{3k} vertices respectively. Construct in P_1 , $S_1 = \{u_s / d(u, u_s) = 0 \text{ or } \geq 2\}$. Clearly, $|S_1| = 3k$. Then, S_1 forms an *ied* set with cardinality $\left\lceil \frac{3k}{3} \right\rceil$. Since $\langle S_1 \rangle$ is a path. Similarly, Construct in P_2 , $S_2 = \{v_t \text{ such that } d(u, v_t) = 0 \text{ or } \geq 2 \text{ and } d(v, v_t) = 0 \text{ or } \geq 2\}$. Clearly, $|S_2| = 3k$. Also it yields an *ied* -set. Then $\gamma_{ied}(S_2) = \left\lceil \frac{3k}{3} \right\rceil = k$. Since $\langle S_2 \rangle$ also path graph. Now, $S = S_1 \cup \{u_1\} \cup S_2 \cup \{u, v\}$ forms an *ied* set. $\gamma_{ied}(S) \leq |S_1| + |S_2| + \{u, v\} \leq 2k + 2$. Claim: for $\lambda = 1, \gamma_{ied}(HC_{1,3k+f}) \geq 2k + 2; f = 1, 2, 3$. Suppose, $\gamma_{ied}(HC_{1,3k+j}) = 2k + 1; f = 1, 2, 3$. If we remove $\{u\}$ or $\{v\}$ then either $S - \{u\} \cup \{l_1, l_2\}$ or $S - \{v\} \cup \{x_1, x_2\}$ gives an *ied*-set respectively. So, $\gamma_{ied}(HC_{1,3k+f}) \geq 2k + 2; f = 1, 2, 3$. Hence $\gamma_{ied}(HC_{1,3k+f}) = 2k + 2; 1 \leq f \leq 3$.

Theorem: 3.3 For $\lambda \geq 1, \gamma_{ied}(HC_{\lambda,3k+j}) = \lambda(2k + 3) - 1; j = 1, 2, 3$.

Proof: Suppose $\lambda \geq 2$. Let $t_1, t_2, t_3, \dots, t_{\lambda+1}$ be the joining vertices of each human-chain. Then $\{t_2, t_3, \dots, t_{\lambda}\}$ must belong to *ied* set of $HC_{\lambda,3k+j}$. Otherwise, suppose $t_m, (m = 2, 3, \dots, \lambda) \in HC_{\lambda,3k+j}$. Then *ied* -set condition does not hold. Therefore γ_{ied} must contain $\{t_m: m = 2, 3, \dots, \lambda\}$. Therefore, $\gamma_{ied}(HC_{\lambda,3k+j}) = \gamma_{ied}(HC_{1,3k+j}) + \gamma_{ied}(HC_{2,3k+j}) + \dots + \gamma_{ied}(HC_{\lambda,3k+j}) + (\lambda - 1)$.

Since, $\gamma_{ied}(HC_{1,3k+j}) = \gamma_{ied}(HC_{2,3k+j}) = \dots = \gamma_{ied}(HC_{\lambda,3k+j})$. (by Theorem 3.2.)
 $= \gamma_{ied}(HC_{1,3k+j}) + \dots + \gamma_{ied}(HC_{1,3k+j}) + (\lambda - 1) = \lambda(2k + 3) - 1; j = 1, 2, 3. (\lambda \text{ times})$

Theorem:3.4 For Circular Human-chain $CHC_{\lambda,m}, \lambda \geq 2, m \geq 3, \gamma_{ied}(CHC_{\lambda,3k+f}) = \lambda(2k + 3) - 1; 1 \leq f \leq 3$.

Proof: The explanation and Solution of Theorem 3.3 are somewhat similar.

Remarks: 3.5

Observation: 3.6

$$\gamma_{ied}(SHC_{2,5} - \{\emptyset_1, \emptyset_2, \emptyset_3, \emptyset_4, \emptyset_5, \emptyset_6\}) \leq \gamma_{ied}(SHC_{2,5}).$$

So, $\gamma_{ied}(SHC_{2,5} - \{\emptyset_1, \emptyset_2, \emptyset_3, \emptyset_4, \emptyset_5, \emptyset_6\}) \leq \lambda(2i + 3) - 1; j = 1, 2, 3$.

Theorem: 3.7

For $\lambda \geq 2, m \geq 36 \leq \gamma_{ied}(SHC_{\lambda,3i+j}) \leq \left\lceil \frac{\lambda(6i+11)}{3} \right\rceil, j = 1, 2, 3; m = 3i + j$.

Proof:

Clearly, $\gamma_{ied}(SHC_{2,3}) = 6$. Let $SHC_{\lambda,m}$ be the strong human-chain network. Let $S = \{e_1, e_2, \dots, e_{\lambda}\}$ coming from Figure 3. Remove Scoring from $SHC_{\lambda,m}$ yields disconnected graph with two components G and P . Since $\langle P \rangle$ is a path graph with $2\lambda + 1$ vertices and hence, Coming from Observation 5.6 and Theorem 2.10, $\gamma_{ied}(SHC_{\lambda,m}) = \gamma_{ied}(G) + \gamma_{ied}(P) \leq \lambda(2i + 3) - 1 + \left\lceil \frac{2\lambda+1}{3} \right\rceil \leq \left\lceil \frac{\lambda(6i+11)}{3} \right\rceil$.





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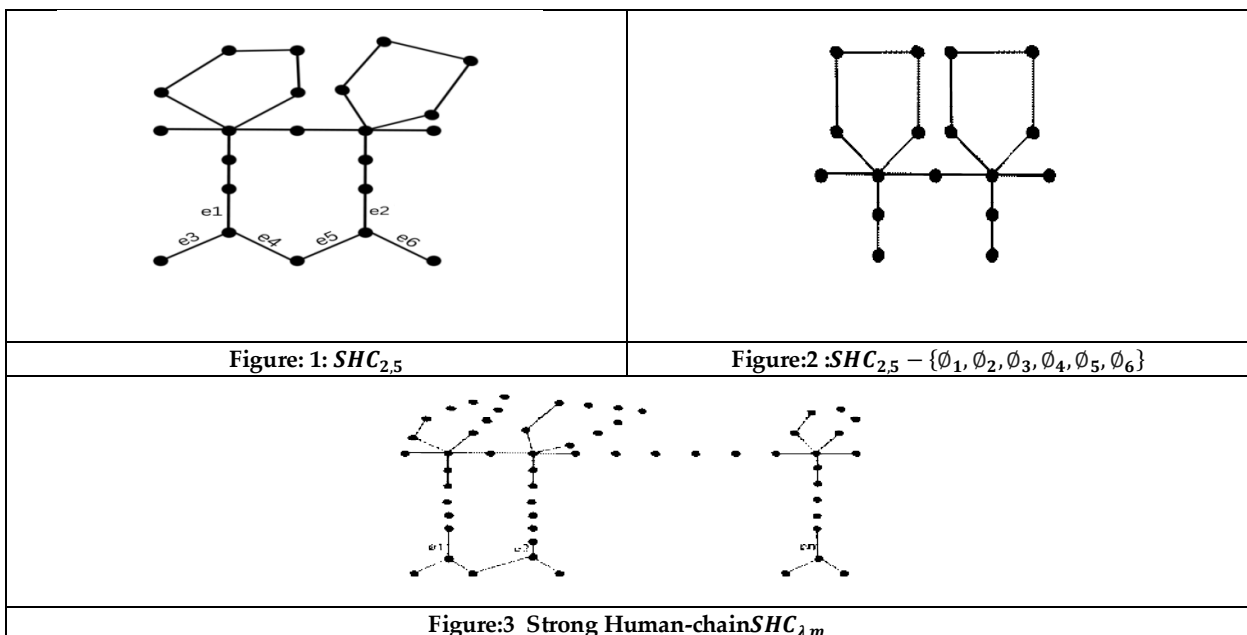
Observation: 3.8 $\gamma_{ied}(WHC_{\lambda,3}) = 2\lambda$ if $\lambda \geq 2$.

Theorem: 3.9 $\gamma_{ied}(WHC_{\lambda,m}) = 2\lambda(p + 1); m = 3p + f; i \geq 1; f = 1,2,3$.

Proof: $\gamma_{ied}(WHC_{1,m}) = \gamma_{ied}(HC_{1,m})$. By Theorem 3.2, $\gamma_{ied}(WHC_{1,m}) = 2p + 2$. So, $\gamma_{ied}(WHC_{\lambda,m}) = 2\lambda(p + 1)$.

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An Extension of Intuitionistic Fuzzy Rough Sets on Similarity Measures

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ABSTRACT

There are many mysteries in the world. Fuzzy sets were developed as a mathematical tool for dealing with ambiguity. Further generalization of fuzzy sets was extended to intuitionistic fuzzy sets contain both membership, non-membership values and its hesitancy. A rough fuzzy set is identified when all components of a set converge on a crisp number as n approaches infinity. In this paper, we propose an extension of Intuitionistic Fuzzy Rough Sets (*IFRS*) on similarity measure. We developed a decision-based method to an intuitionistic fuzzy rough set. Finally, numerical examples have been provided, utilizing decision-making methods to enrich illustration and enhance clarity.

Keywords: Fuzzy sets, Intuitionistic Fuzzy Rough Set, Decision making, Similarity measure.

INTRODUCTION

A Fuzzy sets (FS) invented by renowned and eminent scientist L.A. Zadeh [11] in 1965, has demonstrated significant applications in numerous areas of study. Fuzzy set theory states that if each element is normally assigned a membership values between 0 and 1, then reluctance or uncertainty may prevent the non-membership degree from always equivalent to 1 minus the membership values. Rough set (RS), established by prominent scientist Pawlak [14] in 1996, and is a wide scientific framework adept at handling data characterized by sets of elements, especially when dealing with ambiguity or incomplete data. It defines a rough set as comprising two components: which are the lower and upper approximations (of the target set), both determined by the relation specified within the set. The target set contains the lower approximation, and it may also contain the upper approximation. Further, in the 1980, Atanassov's research on intuitionistic fuzzy sets (IFS) introduced the hesitation margin, which characterizes the uncertainty within each element. This margin, derived from difference of 1 and the total of both membership

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functions and non-membership functions, it delivers a comprehensive perspective on the level of hesitancy present. The conception of characterizing Intuitionistic Fuzzy Sets (IFS) as universal Fuzzy sets is stimulating and beneficial in various domains. Intuitionistic fuzzy sets become most significant, resourceful and appropriate, since they contain both degrees of membership and non-membership function together with hesitation margin, (Atanassov, 1994, 1999) [3]. Nanda & Majumdar [12] was combined the Fuzzy & Rough sets to establish the fuzzy rough sets theory in 1992. As a result, Fuzzy sets are intuitionistic L-fuzzy sets, as noted by Coker [7]. In this article, we use the concept of the Intuitionistic Fuzzy Rough Sets (IFRS) [10] model to find the similar measure between two given Intuitionistic Fuzzy Rough set with 8-tuples. The effectiveness of the more realistic decision-making method is illustrated with a numerical example.

PRELIMINARIES

Definition 1[2]

Suppose that Γ is a universal set and IFS \tilde{A} in Γ is defined as follows $\tilde{A} = \{ \langle \tau, \mu_{\tilde{A}}(\tau), \nu_{\tilde{A}}(\tau) \rangle : \tau \in \Gamma \}$, then each element of membership degree is $\mu_{\tilde{A}} : \tau \rightarrow [0, 1]$ and each element of non-membership degree is $\nu_{\tilde{A}} : \tau \rightarrow [0, 1]$ respectively, for every element $\tau \in \Gamma$, where $0 \leq \mu_{\tilde{A}}(\tau) + \nu_{\tilde{A}}(\tau) \leq 1$. Thus, we have $\alpha_{\tilde{A}}(\tau) = 1 - \mu_{\tilde{A}}(\tau) - \nu_{\tilde{A}}(\tau)$ is said to be the IFS Index or Hesitation Margin. Where, $\alpha_{\tilde{A}}(\tau)$ is the degrees of Indeterminacy, $\alpha_{\tilde{A}}(\tau) \in [0, 1]$ and $0 \leq \alpha_{\tilde{A}}(\tau) \leq 1$, for every element $\tau \in \Gamma$.

Definition 2[3]

Consider the universal set E and IFRS is the Intuitionistic Fuzzy relation is defined by $E \times E$. The pair $(E, IFRS)$ is said to be Intuitionistic Fuzzy Rough approximation. For any $\tilde{A} \in IF(E)$, where $IF(E)$ is denoted by intuitionistic fuzzy power set of E , both lower and upper approximations of \tilde{A} are denoted by $IFR(\tilde{A})$ & $IF\bar{R}(\tilde{A})$. Then it is are defined by:

$$IFR(\tilde{A}) = \{ \langle \tau, \mu_{IFR(\tilde{A})}(\tau), \nu_{IFR(\tilde{A})}(\tau) \rangle : \tau \in E \} \text{ and } IF\bar{R}(\tilde{A}) = \{ \langle \tau, \mu_{IF\bar{R}(\tilde{A})}(\tau), \nu_{IF\bar{R}(\tilde{A})}(\tau) \rangle : \tau \in E \}$$

$$\mu_{IFR(\tilde{A})}(\tau) = \bigcup_{\eta \in E} [\mu_{IFR}(\tau, \eta) \vee \mu_{\tilde{A}}(\eta)] \quad \mu_{IF\bar{R}(\tilde{A})}(\tau) = \bigcap_{\eta \in E} [\nu_{IFR}(\tau, \eta) \vee \nu_{\tilde{A}}(\eta)]$$

Where

$$\mu_{IFR(\tilde{A})}(\tau) = \bigcap_{\eta \in E} [\nu_{IFR}(\tau, \eta) \vee \mu_{\tilde{A}}(\eta)] \quad \nu_{IF\bar{R}(\tilde{A})}(\tau) = \bigcup_{\eta \in E} [\mu_{IFR}(\tau, \eta) \wedge \nu_{\tilde{A}}(\eta)]$$

and

Definition 3[4]

Suppose that the universal set E and $A, B \in IF(E)$. Then

i) The complement of $A = \langle \mu_{\tilde{A}}(\tau), \mu_{\tilde{A}}(\tau), \nu_{\tilde{A}}(\tau), \nu_{\tilde{A}}(\tau) \rangle$ is defined as $A^c = \langle \nu_{\tilde{A}}(\tau), \nu_{\tilde{A}}(\tau), \mu_{\tilde{A}}(\tau), \mu_{\tilde{A}}(\tau) \rangle$ for any $\tau \in E$.

ii) $A \subseteq B$, if for any $\tau \in E$ $\mu_{\tilde{A}}(\tau) \leq \mu_{\tilde{B}}(\tau)$, $\mu_{\tilde{A}}(\tau) \leq \mu_{\tilde{B}}(\tau)$ and $\nu_{\tilde{A}}(\tau) \geq \nu_{\tilde{B}}(\tau)$, $\nu_{\tilde{A}}(\tau) \leq \nu_{\tilde{B}}(\tau)$.





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Definition 4[9]

Suppose that the universal set E and $A \in IFRS(E)$. Then the similarity measure is $\Phi: A \times A \rightarrow [0,1]$ where, $\Phi(x, y)$ is known as similarity degree between the IFRS values are

$$X = (\underline{h}_A(x), \overline{h}_A(x), \underline{\zeta}_A(x), \overline{\zeta}_A(x), \underline{\varphi}_A(x), \overline{\varphi}_A(x)) \quad \text{and}$$

$$Y = (\underline{h}_A(y), \overline{h}_A(y), \underline{\zeta}_A(y), \overline{\zeta}_A(y), \underline{\varphi}_A(y), \overline{\varphi}_A(y)) \quad \text{if } \Phi \text{ satisfies the following conditions:}$$

1. $0 \leq \Phi(x, y) \leq 1$
2. $\Phi(x, y) = \Phi(y, x)$
3. For every $x \in A$, $\Phi(x, y) = \Phi(x, z) \Rightarrow \Phi(y, z) = 1$
4. $\Phi(x, y) = \Phi(x^c, y^c)$ Where, x^c & y^c are complements of x and y respectively.
5. If $x \leq y \leq z$, then $\Phi(x, z) \leq \min\{\Phi(x, y), \Phi(y, z)\}, \forall x, y, z \in A$.

Similarity Measures of an extended IFRS

The goal of more than of research [[6], [17], [18], and [19]] has been to enhance the *IFRS* and IFS similarity measure model. Based on the set-theoretic method, Pappis and Karcapilidis [13] defined the similar measure between the fuzzy sets P and Q . Where $p_i \in \ddot{P}$ and $q_i \in \ddot{Q}$ as follows.

$$\Phi_f(\ddot{P}, \ddot{Q}) = \frac{|\ddot{P} \cap \ddot{Q}|}{|\ddot{P} \cup \ddot{Q}|} = \frac{\sum_i^n (p_i \wedge q_i)}{\sum_i^n (p_i \vee q_i)}$$

In Chen[6] was defined by a similarity measure between two *IFS* values of \ddot{p} and \ddot{q} are as follows:

$$\Phi_c(p, q) = \frac{\min(\underline{h}(\ddot{p}), \underline{h}(\ddot{q})) + \min(\underline{\zeta}(\ddot{p}), \underline{\zeta}(\ddot{q})) + \min(\underline{\varphi}(\ddot{p}), \underline{\varphi}(\ddot{q}))}{\max(\underline{h}(\ddot{p}), \underline{h}(\ddot{q})) + \max(\underline{\zeta}(\ddot{p}), \underline{\zeta}(\ddot{q})) + \max(\underline{\varphi}(\ddot{p}), \underline{\varphi}(\ddot{q}))}$$

Definition 5[3]

Consider a Fuzzy Rough Set $A \in \Gamma$ and $\ddot{p} = \langle \underline{h}_A(\ddot{p}), \overline{h}_A(\ddot{p}) \rangle$ & $\ddot{q} = \langle \underline{h}_A(\ddot{q}), \overline{h}_A(\ddot{q}) \rangle$

are the Fuzzy Rough values in A . Then the degrees of a similarity between Fuzzy Rough values of \ddot{p} and \ddot{q} are computed by the following equation:

$$\Phi_z(\ddot{p}, \ddot{q}) = 1 - \frac{1}{2} (|\underline{h}_A(\ddot{p}) - \underline{h}_A(\ddot{q})| + |\overline{h}_A(\ddot{p}) - \overline{h}_A(\ddot{q})|)$$

Definition 6

Suppose that A is an *IFRS* in Γ . Consider a two *IF* rough values are

$$\ddot{p} = (\underline{h}_A(\ddot{p}), \overline{h}_A(\ddot{p}), \underline{\zeta}_A(\ddot{p}), \overline{\zeta}_A(\ddot{p}), \underline{\varphi}_A(\ddot{p}), \overline{\varphi}_A(\ddot{p}), \underline{\lambda}_A(\ddot{p}), \overline{\lambda}_A(\ddot{p})) \quad \text{and}$$

$$\ddot{q} = (\underline{h}_A(\ddot{q}), \overline{h}_A(\ddot{q}), \underline{\zeta}_A(\ddot{q}), \overline{\zeta}_A(\ddot{q}), \underline{\varphi}_A(\ddot{q}), \overline{\varphi}_A(\ddot{q}), \underline{\lambda}_A(\ddot{q}), \overline{\lambda}_A(\ddot{q}))$$





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Then the degrees of similarity measure between the two *IF* rough values of \ddot{p} and \ddot{q} as defined by:

$$\Phi_k(\ddot{p}, \ddot{q}) = \frac{(\underline{h}_A(\ddot{p}) \wedge \underline{h}_A(\ddot{q})) + (\underline{h}_A(\ddot{p}) \wedge \underline{h}_A(\ddot{q})) + (\underline{\zeta}_A(\ddot{p}) \wedge \underline{\zeta}_A(\ddot{q})) + (\underline{\zeta}_A(\ddot{p}) \wedge \underline{\zeta}_A(\ddot{q})) + (\underline{\varphi}_A(\ddot{p}) \wedge \underline{\varphi}_A(\ddot{q})) + (\underline{\varphi}_A(\ddot{p}) \wedge \underline{\varphi}_A(\ddot{q})) + (\underline{\lambda}_A(\ddot{p}) \wedge \underline{\lambda}_A(\ddot{q})) + (\underline{\lambda}_A(\ddot{p}) \wedge \underline{\lambda}_A(\ddot{q}))}{(\underline{h}_A(\ddot{p}) \vee \underline{h}_A(\ddot{q})) + (\underline{h}_A(\ddot{p}) \vee \underline{h}_A(\ddot{q})) + (\underline{\zeta}_A(\ddot{p}) \vee \underline{\zeta}_A(\ddot{q})) + (\underline{\zeta}_A(\ddot{p}) \vee \underline{\zeta}_A(\ddot{q})) + (\underline{\varphi}_A(\ddot{p}) \vee \underline{\varphi}_A(\ddot{q})) + (\underline{\varphi}_A(\ddot{p}) \vee \underline{\varphi}_A(\ddot{q})) + (\underline{\lambda}_A(\ddot{p}) \vee \underline{\lambda}_A(\ddot{q})) + (\underline{\lambda}_A(\ddot{p}) \vee \underline{\lambda}_A(\ddot{q}))}$$

Thus, the higher values of $\Phi_k(\ddot{p}, \ddot{q})$ is the more the similarity between the *IF* Rough values of \ddot{p} and \ddot{q} .

Example 1

Consider $\ddot{p} = (0.8, 0.3, 0.5, 0.1, 0.2, 0.3, 0.7, 0.2)$ and $\ddot{q} = (0.9, 0.7, 0.3, 0.05, 0.1, 0.2, 0.5, 0.1)$ are the two *IF* rough values. Then the degrees of similarity between the sets \ddot{p} and \ddot{q} as determined by

$$\Phi_k(\ddot{p}, \ddot{q}) = \frac{\min(0.8, 0.9) + \min(0.3, 0.7) + \min(0.5, 0.3) + \min(0.1, 0.05) + \min(0.2, 0.1) + \min(0.3, 0.2) + \min(0.7, 0.5) + \min(0.2, 0.1)}{\max(0.8, 0.9) + \max(0.3, 0.7) + \max(0.5, 0.3) + \max(0.1, 0.05) + \max(0.2, 0.1) + \max(0.3, 0.2) + \max(0.7, 0.5) + \max(0.2, 0.1)}$$

$$\Phi_k(\ddot{p}, \ddot{q}) = \frac{0.8 + 0.3 + 0.3 + 0.05 + 0.1 + 0.2 + 0.5 + 0.1}{0.9 + 0.7 + 0.5 + 0.1 + 0.2 + 0.3 + 0.7 + 0.2} = 0.65278.$$

Example 2

Consider $\ddot{p} = (0.9, 0.5, 0.4, 0.3, 0.7, 0.1, 0.4, 0.3)$ and $\ddot{q} = (0.8, 0.6, 0.7, 0.2, 0.1, 0.05, 0.25, 0.1)$ are the two *IF* rough values. Then the complementary of \ddot{p} and \ddot{q} as determined by $p^c = (0.4, 0.3, 0.9, 0.5, 0.4, 0.3, 0.7, 0.1)$ and $q^c = (0.7, 0.2, 0.8, 0.6, 0.25, 0.1, 0.1, 0.05)$. Hence the degree of similarity between p^c and q^c can be determined by

$$\Phi_k(p^c, q^c) = \frac{\min(0.4, 0.7) + \min(0.3, 0.2) + \min(0.9, 0.8) + \min(0.5, 0.6) + \min(0.4, 0.25) + \min(0.3, 0.1) + \min(0.7, 0.1) + \min(0.1, 0.05)}{\max(0.4, 0.7) + \max(0.3, 0.2) + \max(0.9, 0.8) + \max(0.5, 0.6) + \max(0.4, 0.25) + \max(0.3, 0.1) + \max(0.7, 0.1) + \max(0.1, 0.05)}$$

$$\Phi_k(p, q) = \frac{0.4 + 0.2 + 0.8 + 0.5 + 0.25 + 0.1 + 0.1 + 0.05}{0.7 + 0.3 + 0.9 + 0.6 + 0.4 + 0.3 + 0.7 + 0.1} = 0.64103.$$

Theorem 1

1. Let A be the *IFRS* Γ , where $\ddot{p}, \ddot{q}, \ddot{r}$ are the *IF* rough values A. then the following conditions are true
2. $\Phi_k(\ddot{p}, \ddot{q})$ is bounded i.e., $0 \leq \Phi_k(\ddot{p}, \ddot{q}) \leq 1$.
3. $\Phi_k(\ddot{p}, \ddot{q}) = \Phi_k(\ddot{q}, \ddot{p})$.
4. $\Phi_k(\ddot{p}, \ddot{q}) = \Phi_k(\ddot{p}, \ddot{r}) \Rightarrow \Phi_k(\ddot{q}, \ddot{r}) = 1$.
5. $\Phi_k(\ddot{p}, \ddot{q}) = \Phi_k(p^c, q^c)$.
6. If $\ddot{p} \leq \ddot{q} \leq \ddot{r}$, then $\Phi_k(\ddot{p}, \ddot{r}) = \min\{\Phi_k(\ddot{p}, \ddot{q}), \Phi_k(\ddot{q}, \ddot{r})\}, \forall p, q, r \in \Gamma$.

Proof

Suppose that A be a *IFRS* in Γ .

$$\ddot{p} = (\underline{h}_A(\ddot{p}), \underline{h}_A(\ddot{p}), \underline{\zeta}_A(\ddot{p}), \underline{\zeta}_A(\ddot{p}), \underline{\varphi}_A(\ddot{p}), \underline{\varphi}_A(\ddot{p}), \underline{\lambda}_A(\ddot{p}), \underline{\lambda}_A(\ddot{p})),$$





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$$\ddot{q} = (\underline{h}_A(\ddot{q}), \underline{h}_A(\ddot{q}), \underline{\zeta}_A(\ddot{q}), \underline{\zeta}_A(\ddot{q}), \underline{\varphi}_A(\ddot{q}), \underline{\varphi}_A(\ddot{q}), \underline{\lambda}_A(\ddot{q}), \underline{\lambda}_A(\ddot{q})) \&$$

$$\ddot{r} = (\underline{h}_A(\ddot{r}), \underline{h}_A(\ddot{r}), \underline{\zeta}_A(\ddot{r}), \underline{\zeta}_A(\ddot{r}), \underline{\varphi}_A(\ddot{r}), \underline{\varphi}_A(\ddot{r}), \underline{\lambda}_A(\ddot{r}), \underline{\lambda}_A(\ddot{r}))$$

are the *IFRS* values A. we can defined by the order relation of *IFRS* values as

$$\ddot{p} \leq \ddot{q} \Leftrightarrow (\underline{h}_A(\ddot{p}) \leq \underline{h}_A(\ddot{q}), \underline{h}_A(\ddot{p}) \leq \underline{h}_A(\ddot{q})) \& (\underline{v}_A(\ddot{p}) \geq \underline{v}_A(\ddot{q}), \underline{v}_A(\ddot{p}) \geq \underline{v}_A(\ddot{q}))$$

1. From condition (v), we get the minimum and maximum values are 0 and 1. In other cases, a numerator value is smaller than the denominator value. Thus, the condition (v) must have a positive value that is less than one.

Thus, $0 \leq \Phi_k(\ddot{p}, \ddot{q}) \leq 1$

2. Since both the maximum and minimum procedures are symmetric, Φ_k is symmetric.

3. Since $\Phi_k(\ddot{p}, \ddot{q}) = \Phi_k(\ddot{p}, \ddot{r}) \forall p \in \Gamma$. Then for $p = q$, $1 = \Phi_k(\ddot{q}, \ddot{q}) = \Phi_k(\ddot{q}, \ddot{r})$. Similarly, for $\ddot{p} = \ddot{r}$ & $p = r$. Thus $1 = \Phi_k(\ddot{r}, \ddot{r}) = \Phi_k(\ddot{r}, \ddot{q}) = \Phi_k(\ddot{q}, \ddot{r})$

4. In the case $p^c = (\underline{\zeta}_A(\ddot{p}), \underline{\zeta}_A(\ddot{p}), \underline{h}_A(\ddot{p}), \underline{h}_A(\ddot{p}), \underline{\lambda}_A(\ddot{p}), \underline{\lambda}_A(\ddot{p}), \underline{\varphi}_A(\ddot{p}), \underline{\varphi}_A(\ddot{p}))$ and $p^c = (\underline{\zeta}_A(\ddot{q}), \underline{\zeta}_A(\ddot{q}), \underline{h}_A(\ddot{q}), \underline{h}_A(\ddot{q}), \underline{\lambda}_A(\ddot{q}), \underline{\lambda}_A(\ddot{q}), \underline{\varphi}_A(\ddot{q}), \underline{\varphi}_A(\ddot{q}))$. Thus, $\Phi_k(\ddot{p}, \ddot{q}) = \Phi_k(p^c, q^c)$

5. Given $\ddot{p} \leq \ddot{q} \leq \ddot{r}$. Substituting $\underline{\varphi}_A(\ddot{p}), \underline{\varphi}_A(\ddot{p}), \underline{\varphi}_A(\ddot{r}), \underline{\varphi}_A(\ddot{r})$ we get, $\Phi_k(\ddot{p}, \ddot{r}) = \frac{1 - \underline{Y}_{pr} + 1 - \overline{Y}_{pr}}{1 + \underline{Y}_{pr} + 1 + \overline{Y}_{pr}}$, where $\underline{Y}_{pr} = (\underline{h}_A(\ddot{r}) - \underline{h}_A(\ddot{p})) \vee (\underline{\zeta}_A(\ddot{p}) - \underline{\zeta}_A(\ddot{r}))$ & $\overline{Y}_{pr} = (\underline{h}_A(\ddot{r}) - \underline{h}_A(\ddot{p})) \vee (\underline{\zeta}_A(\ddot{p}) - \underline{\zeta}_A(\ddot{r}))$.

$$\Phi_k(\ddot{p}, \ddot{q}) = \frac{1 - \overline{Y}_{pq} + 1 - \underline{Y}_{pq}}{1 + \overline{Y}_{pq} + 1 + \underline{Y}_{pq}} \quad \text{where} \quad \underline{Y}_{pq} = (\underline{h}_A(\ddot{q}) - \underline{h}_A(\ddot{p})) \vee (\underline{\zeta}_A(\ddot{p}) - \underline{\zeta}_A(\ddot{q})) \&$$

$$\overline{Y}_{pq} = (\underline{\mu}_A(\ddot{q}) - \underline{\mu}_A(\ddot{p})) \vee (\underline{v}_A(\ddot{p}) - \underline{v}_A(\ddot{q})) \quad \text{Clearly,} \quad (1 - \overline{Y}_{pr} + 1 - \underline{Y}_{pr}) \leq (1 - \overline{Y}_{pq} + 1 - \underline{Y}_{pq}) \quad \text{as}$$

$$\underline{Y}_{pr} \geq \underline{Y}_{pq} \quad \text{and} \quad \overline{Y}_{pr} \geq \overline{Y}_{pq} \quad \text{and} \quad (1 + \underline{Y}_{pr} + 1 + \overline{Y}_{pr}) \geq (1 + \underline{Y}_{pq} + 1 + \overline{Y}_{pq}) \quad \text{as}$$

$$\underline{Y}_{pr} \geq \underline{Y}_{pq} \quad \text{and} \quad \overline{Y}_{pr} \geq \overline{Y}_{pq} \quad \text{Hence} \quad \Phi_k(\ddot{p}, \ddot{r}) \leq \Phi_k(\ddot{p}, \ddot{q}) \quad \text{Similarly,} \quad \Phi_k(\ddot{p}, \ddot{r}) \leq \Phi_k(\ddot{q}, \ddot{r})$$

Proposition 1

The generalization of the similarity measure between two given *IFRS*. Let A and B be two *IFRS* in the universal

set $\Gamma = \{\tau_1, \tau_2, \tau_3, \dots, \tau_n\}$. Where,

$$\ddot{A} = \langle \underline{h}_A(\tau_1), \underline{h}_A(\tau_1), \underline{\zeta}_A(\tau_1), \underline{\zeta}_A(\tau_1), \underline{\varphi}_A(\tau_1), \underline{\varphi}_A(\tau_1), \underline{\lambda}_A(\tau_1), \underline{\lambda}_A(\tau_1) \rangle / \tau_1 + \dots$$

$$+ \langle \underline{h}_A(\tau_n), \underline{h}_A(\tau_n), \underline{\zeta}_A(\tau_n), \underline{\zeta}_A(\tau_n), \underline{\varphi}_A(\tau_n), \underline{\varphi}_A(\tau_n), \underline{\lambda}_A(\tau_n), \underline{\lambda}_A(\tau_n) \rangle / \tau_n \quad \&$$

$$\ddot{B} = \langle \underline{h}_B(\tau_1), \underline{h}_B(\tau_1), \underline{\zeta}_B(\tau_1), \underline{\zeta}_B(\tau_1), \underline{\varphi}_B(\tau_1), \underline{\varphi}_B(\tau_1), \underline{\lambda}_B(\tau_1), \underline{\lambda}_B(\tau_1) \rangle / \tau_1 + \dots$$

$$+ \langle \underline{h}_B(\tau_n), \underline{h}_B(\tau_n), \underline{\zeta}_B(\tau_n), \underline{\zeta}_B(\tau_n), \underline{\varphi}_B(\tau_n), \underline{\varphi}_B(\tau_n), \underline{\lambda}_B(\tau_n), \underline{\lambda}_B(\tau_n) \rangle / \tau_n$$

From definition 5, can define similarity measure between the *IFRS* A and B as follows:





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$$\tilde{\Phi}_k(\ddot{A}, \ddot{B}) = \frac{1}{m} \sum_{z=1}^n \Phi_k((\hbar_{\underline{A}}(\tau_z), \hbar_{\overline{A}}(\tau_z), \zeta_{\underline{A}}(\tau_z), \zeta_{\overline{A}}(\tau_z), \varphi_{\underline{A}}(\tau_z), \varphi_{\overline{A}}(\tau_z), \lambda_{\underline{A}}(\tau_z), \lambda_{\overline{A}}(\tau_z)),$$

$$(\mu_{\underline{B}}(\tau_i), \mu_{\overline{B}}(\tau_i), \nu_{\underline{B}}(\tau_i), \nu_{\overline{B}}(\tau_i), \varphi_{\underline{B}}(\tau_i), \varphi_{\overline{B}}(\tau_i), \gamma_{\underline{B}}(\tau_i), \gamma_{\overline{B}}(\tau_i)))$$

Thus,

$$\tilde{\Phi}_k(\ddot{A}, \ddot{B}) = \frac{1}{m} \sum_{z=1}^n \left(\frac{\min(\hbar_{\underline{A}}(\tau_z), \hbar_{\underline{B}}(\tau_z)) + \min(\hbar_{\overline{A}}(\tau_z), \hbar_{\overline{B}}(\tau_z)) + \min(\zeta_{\underline{A}}(\tau_z), \zeta_{\underline{B}}(\tau_z)) + \min(\zeta_{\overline{A}}(\tau_z), \zeta_{\overline{B}}(\tau_z))}{\max(\hbar_{\underline{A}}(\tau_z), \hbar_{\underline{B}}(\tau_z)) + \max(\hbar_{\overline{A}}(\tau_z), \hbar_{\overline{B}}(\tau_z)) + \max(\zeta_{\underline{A}}(\tau_z), \zeta_{\underline{B}}(\tau_z)) + \max(\zeta_{\overline{A}}(\tau_z), \zeta_{\overline{B}}(\tau_z))} \right.$$

$$\left. \frac{\min(\varphi_{\underline{A}}(\tau_z), \varphi_{\underline{B}}(\tau_z)) + \min(\varphi_{\overline{A}}(\tau_z), \varphi_{\overline{B}}(\tau_z)) + \min(\lambda_{\underline{A}}(\tau_z), \lambda_{\underline{B}}(\tau_z)) + \min(\lambda_{\overline{A}}(\tau_z), \lambda_{\overline{B}}(\tau_z))}{\max(\varphi_{\underline{A}}(\tau_z), \varphi_{\underline{B}}(\tau_z)) + \max(\varphi_{\overline{A}}(\tau_z), \varphi_{\overline{B}}(\tau_z)) + \max(\lambda_{\underline{A}}(\tau_z), \lambda_{\underline{B}}(\tau_z)) + \max(\lambda_{\overline{A}}(\tau_z), \lambda_{\overline{B}}(\tau_z))} \right) \dots (1)$$

Decision making method

Now, we construct the algorithm for an extension of an *IFRS* on similarity measure.

- Step 1: Constructs the *IFRS* for a standard alternative.
- Step 2: Constructs the *IFRS* for an available alternative.
- Step 3: Computes the similar measure.
- Step 4: Arrange alternatives in descending order to their ranking.
- Step 5: Choose the maximum value is considered as the best option.

Numerical Example

A company has to fire an employee for a manager post that is empty. Eight applicants complete a form and submit their formal application for the position. The head of the human resources department has been a decision-maker. Suppose that the set of candidates $X=(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8)$ and $E=(b_1, b_2, b_3, b_4, b_5)$ the set of parameters. b_1 =Communication, b_2 = effectiveness of their leadership, b_3 = experience, b_4 = administration and b_5 =age.

Computation

Step 1: Let E be the standard alternatives.

$$E=(0.5,1,0.4,0.79,0,0.6,0.054,1)/b_1+(0,0.08,0.6,0.4,0.5,0.07,1,0.59)/b_2+(0.65,0.53,0.07,1,0,0.7,0.54,0.2)/$$

$$b_3+(0.74,0.5,1,0.22,0,0.3,0.41,0.89)/b_4+(0.97,0,0.07,0.54,1,0.99,0.1,0.59)/b_5$$

Step 2: Suppose that $X_1, X_2, X_3, X_4, X_5, X_6, X_7$ and X_8 are the available alternatives.

$$X_1=(0.9,0.67,0.02,1,0.43,0.31,0.99,0)/b_1+(0.7,1,0.65,0.99,0,0.9,0.73,0.16)/b_2+(0.09,0.1,0.06,0.03,1,0.75,0.2,0)/b_3+(1,0.01,0.27,0.$$

$$39,0.5,0.2,0.36,0)/b_4+(0.94,0.7,0.33,0.5,0.74,0.41,0.93)/b_5$$

$$X_2=(0.2,0.01,0.9,0.99,0.5,0.8,0.5,1)/b_1+(1,1,0.31,0.66,0.6,0.5,0.45,0.63)/b_2+(0.51,0.5,0.6,0.1,0.7,0.77,0.28,0.7)/b_3+(0.19,0.9,0.07,$$

$$0.1,0.29,0.2,0,0)/b_4+(1,0.06,0.22,0,0.25,0.74,0.09,0.04)/b_5$$

$$X_3=(0.4,0.49,0.07,1,0,0.8,0.7,0.32)/b_1+(0.29,0.3,0.01,0.2,1,0.5,0.55,0)/b_2+(0.04,0.47,0.73,0.1,0,0.7,0.2,1)/b_3+(0.47,0.68,0.7,0.9,0.$$

$$7,0.76,0.8,0.1)/b_4+(0.3,0.1,1,0.4,0.46,0.5,0.5,0)/b_5$$

$$X_4=(0.43,0.1,0.25,1,0.5,0.27,0.3,0.88)/b_1+(0.1,0.01,0.57,0.03,0.95,0.99,0.02,0.3)/b_2+(0.04,0.23,0.2,0.56,1,0.79,0.9,0)/b_3+(1,0.34,$$

$$0.5,0.23,0,0.59,0.88,0.8)/b_4+(0.59,0.95,0.14,0.33,0.06,0.73,0.7,0.5)/b_5$$

$$X_5=(0.05,0.54,0.7,0.1,0.1,0.74,0.65,0.16)/b_1+(1,0.06,0.44,0.04,0.5,0.75,0,0.99)/b_2+(0.54,0.76,0.5,0.92,0.92,0.002,1,0.7)/b_3+(0.9,0$$

$$.24,0.4,0.31,0.07,0,0.3,0.1)/b_4+(1,0.2,0.008,0.33,0.53,0.34,0.54,0.06)/b_5$$





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$$X_6=(0,0.1,0.43,0.87,0.4,0.07,1,0.74)/b_1+(0.5,0.01,0.7,0.8,1,0,0.24,0.09)/b_2+(1,0,0.07,0.55,0.22,0.75,0.2,0.7)/e_3+(0.06,0.1,0.2,0.1,0.1,0.57,0.66)/b_4+(0.1,0.35,0,1,0.63,0,0,0.5)/b_5$$

$$X_7=(0.08,0.67,0.01,0.05,0.5,1,0.53,0.77)/b_1+(0.13,0.55,0,0,0.43,0.37,0.94,0.5)/b_2+(0,0.04,0.99,0.4,0.41,0.1,0.5,0.73)/e_3+(0.11,0.4,0.23,0.76,0.33,0.76,0,0.05)/b_4+(1,0.85,0.9,0.086,0,0.29,0.07,0.96)/b_5$$

$$X_8=(0,0.9,0.04,0.1,0.73,1,1,0.3)/b_1+(0.79,0.85,0.6,0.7,0,0.02,0.3,0.5)/b_2+(0,1,0.24,0.7,0.54,0.98,0.2,0.24)/b_3+(0.74,0.07,0.27,0,0.8,0,0.68,0)/b_4+(0,0.74,0.4,0.33,0.5,1,0.74,0.72)/b_5$$

Step 3: compute similarity measure by using Equation (1)

$$\tilde{\Phi}_k(E, X_1) = \frac{1}{4} \left[\frac{2.344}{6.32} + \frac{2.04}{6.33} + \frac{1.18}{4.74} + \frac{1.8}{4.99} + \frac{2.33}{6.48} \right] = 0.4156$$

Similarly, we get

$$\tilde{\Phi}_k(E, X_2) = 0.5068, \tilde{\Phi}_k(E, X_3) = 0.4726, \tilde{\Phi}_k(E, X_4) = 0.5757, \tilde{\Phi}_k(E, X_5) = 0.5119, \\ \tilde{\Phi}_k(E, X_6) = 0.4933, \tilde{\Phi}_k(E, X_7) = 0.4213 \text{ and } \tilde{\Phi}_k(E, X_8) = 0.4646$$

Step 4: If we sort the alternatives in descending order by value $\tilde{\Phi}_k(E, X_i)$. The ranking values are shown below,

Table 1: The assessment score of each alternative

Candidates	Score	Ranking order
X ₁	0.4156	8
X ₂	0.5068	3
X ₃	0.4726	5
X ₄	0.5757	1
X ₅	0.5119	2
X ₆	0.4933	4
X ₇	0.4213	7
X ₈	0.4646	6

Step 5: Thus, we get, X₄>X₅>X₂>X₆>X₃>X₈>X₇>X₁. Hence, X₄ is the best candidate of the manager position.

CONCLUSIONS

In the current article, we propose a model or method for determining the similarity measure in extensions of *IFRS* that is based on fuzzy sets. This model's primary characteristic is that the hesitation margin has been taken into consideration and computed. We also provide some metrics for comparing the similarity of *IFRS* and elements. Ultimately, we used the suggested Decision Making process to solve the problem in real life and arrive at the best possible conclusion.



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The Subdivision of k Heronian Mean Labeling of Some Planar Graphs

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ABSTRACT

In this paper, we extend to the subdivision of k Heronian mean labeling (k – HML) of graphs. We demonstrate that k-heroiner mean graphs (k – HMG) are made up of subdivisions. In this section, we go over a few common planar graphs that allow for the subdivision of k heronian mean labeling (k – HML).

Keywords: Mean labeling Graph, Heronian Mean Labeling Graph, k - Heronian Mean Labeling Graph, subdivision of Heronian Mean Labeling Graph.

MSC: 05C78

INTRODUCTION

Throughout the study, each graph is regarded as a single, simple, undirected, finite planar graph, with l and m representing G 's vertex and edge sets respectively. Labeling a graph involves assigning integer values to a vertex set, an edge set, or both. Many writers presented various labeling modules. A thorough analysis of the labeling graph assignment is shown in [1]. Somasundaram et al. (2013) provided a description of the ML of graphs. The HML of graphs concept was introduced in 2017 by S. Sandhya et al. [7], deriving inspiration from the work of S. Somasundaram. 2017 [4] saw the presentation and discussion of k – HMLG by M Tamilselvi and K Akilandeswari.

$P_n \odot k_1$, L_n , and T_n 's the subdivision of k – HML is examined in this paper.





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Definition: 1.1

A graph that contains l vertex and m edge is represented by $G=(V, E)$. Now create a function that says, $\ell: V \rightarrow \{1,2,3,4,\dots, m+1\}$ is known as HML for the given graph G if we can label the vertices $l \in V$ with different rudiments from similar $1,2,3,4,\dots,m+1$ in order that the induced edge labeling provides $\ell^*: E \rightarrow \{1,2,3,4,\dots, m\}$

given by
$$\ell(e) = \left\lfloor \frac{\ell(a) + \sqrt{\ell(a)\ell(b) + \ell(b)}}{3} \right\rfloor$$

Is varied for every edge $e=ab \in E$. It implies that the graph’s distinct vertex labeling results in a different edge labeling. A HMLG is a graph that possesses HML.

Definition: 1.2

A graph which contain l vertex and m edge is represented by $G=(V, E)$. Now, build a function say, $\ell: V \rightarrow \{k+0, k+1, k+2, k+3,\dots, k+m\}$ is known as k - HML for the given graph G if we can label the vertices $l \in V$ with different rudiments from similar $1,2,3,4,\dots,m+1$ in order that it provides an edge labeling

$\ell^*: E \rightarrow \{k+1, k+2, k+3, k+4,\dots, k+m\}$ given as
$$\ell(e) = \left\lfloor \frac{\ell(a) + \sqrt{\ell(a)\ell(b) + \ell(b)}}{3} \right\rfloor$$

Is varied for every edges $e=ab \in E$. It implies that the graph’s distinct vertex labeling results in a different edge labeling. A k - HML is a graph that possesses k - HML.

Definition: 1.3

A graph is said to be a comb which is obtained by adding a complete graph K_1 to each vertex of an open walk with distinct points and $2n-1$ edges. In general, the comb is given by $P_n \odot K_1$.

Definition: 1.4

A graph is said to be a Ladder, which is defined and denoted by $L_n = P_n \times K_2$, where P_n represents an n - vertices path, \times represents the Cartesian product and K_2 represents a two – vertices full network with $2n$ vertices and $3n-2$ edges.

Definition: 1.5

A graph is said to a Triangular Snake, which is defines the limits by connecting each pair of vertices of a distinct open walk to new vertex. A cyclic graph C_3 with $2n+1$ vertices and $3n$ edges may be used to reestablish each edge of an open walk with distinct vertices. In general, it is denoted by T_n .

Definition: 1.6

When the edges ac and cb substitute for e , it is said to be subdivided if $e=ab$ of G and it as no vertex c . the subdivision is formed by reducing each edge of the graph by $S(G)$.





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MAIN RESULT

Theorem 2.1

Each comb's $(P_n \Theta k_1)$ subdivision is a $k - HM$.

Proof

Comb may exist by linking each vertex of an open walk with different vertices and $2n - 1$ edges with a complete graph K_1 .

A graph $G = S(P_n \Theta K_1)$ obtain by subdividing each and every edges of $P_n \Theta K_1$

A mapping or function $\ell: V \rightarrow \{k + 0, k + 1, k + 2, k + 3, \dots, k + m\}$ is defined and consider for the subsequent scenarios

Case (1)

A subdivision of a Comb $P_n \Theta K_1$ is obtained by subdividing each and every edge $a_j a_{j+1}$ of $P_n \Theta K_1$

On subdividing each and every edge a_j and a_{j+1} we obtain a new vertex $f_j, j \in [1, n - 1]$.

By defined function ℓ the vertices are labeled as

$$\begin{aligned} \ell(a_j) &= 3j - 2 + k / j \text{ in } [1, n] \\ \ell(b_j) &= 3j - 3 + k / j \text{ in } [1, n] \\ \ell(f_j) &= 3j - 1 + k / j \text{ in } [1, n - 1] \end{aligned}$$

The edges are labeled as

$$\begin{aligned} \ell(a_j b_j) &= 3j - 3 + k / j \text{ in } [1, n] \\ \ell(a_j f_j) &= 3j - 2 + k / j \text{ in } [1, n] \\ \ell(f_j a_{j+1}) &= 3j - 1 + k / j \text{ in } [1, n] \end{aligned}$$

Therefore, ℓ is obviously satisfied $k - HML$.

Case (2)

A subdivision of a Comb $P_n \Theta K_1$ is obtained by subdividing each and every edges $a_j b_j$ of $P_n \Theta K_1$

On subdividing each and every edges a_j and b_j we obtain new vertex $g_j, j \in [1, n]$. By defined function ℓ the vertices are labeled as





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$$\begin{aligned} \ell(a_j) &= 3j - 3 + k / j \text{ in } [1, n] \\ \ell(b_j) &= 3j - 1 + k / j \text{ in } [1, n] \\ \ell(g_j) &= 3j - 2 + k / j \text{ in } [1, n] \end{aligned}$$

The edges are labeled as

$$\begin{aligned} \ell(a_j a_{j+1}) &= 3j - 3 + k / j \text{ in } [1, n - 1] \\ \ell(a_j g_j) &= 3j - 2 + k / j \text{ in } [1, n] \\ \ell(g_j b_j) &= 3j - 1 + k / j \text{ in } [1, n] \end{aligned}$$

Therefore, ℓ is obviously satisfied k - HML.

Case (3)

A subdivision of a Comb $P_n \odot K_1$ is obtained by subdividing each and every edges of $P_n \odot K_1$.
On subdividing each and every edges a_j and a_{i+1} we obtain a new vertex $f_j, j \in [1, n - 1]$.

On subdividing each and every edges a_j and b_j we obtain a new vertex $g_j, j \in [1, n]$.

By defined function ℓ the vertices are labeled as

$$\begin{aligned} \ell(a_j) &= 4j - 4 + k / j \text{ in } [1, n] \\ \ell(b_j) &= 4j - 2 + k / j \text{ in } [1, n] \\ \ell(f_j) &= 4j - 1 + k / j \text{ in } [1, n - 1] \\ \ell(g_j) &= 4j - 3 + k / j \text{ in } [1, n] \end{aligned}$$

The edges are labeled as

$$\begin{aligned} \ell(a_j f_j) &= 4j - 2 + k / j \text{ in } [1, n - 1] \\ \ell(f_j a_{i+1}) &= 4j - 1 + k / j \text{ in } [1, n] \\ \ell(a_j g_j) &= 4j - 4 + k / j \text{ in } [1, n] \\ \ell(g_j b_j) &= 4j - 3 + k / j \text{ in } [1, n] \end{aligned}$$

Therefore, ℓ is obviously satisfied k - HML.

Hence, we can conclude that the graph $G = S(P_n \odot K_1)$ is a k - HMLG by the beyond cases.

Example 2.1: The subdivision of k - HML of the Comb $P_5 \odot K_1$ is given in the Fig:2.1,2.2 & 2.3





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Theorem 2.2

Every Ladder (L_n) subdivision is k – HMG
 Proof:

Ladder $L_n = P_n \times K_2$, where P_n represents an n - vertices path, \times represents the Cartesian product and K_2 represents a two – vertices full network with $2n$ vertices and $3n-2$ edges.

A graph $G = S(L_n = P_n \times K_2)$ obtain by subdividing each and every edges of $L_n = P_n \times K_2$

A mapping or function $\ell: V \rightarrow \{k + 0, k + 1, k + 2, k + 3, \dots, k + m\}$ is defined and consider for the subsequent scenarios

Case (1):

A subdivision of a Ladder $L_n = P_n \times K_2$ is achieved by splitting each and every edge $a_j a_{j+1}$ and $b_j b_{j+1}$

On subdividing each and every edge $a_j a_{j+1}$ and $b_j b_{j+1}$ we obtain a new vertices $f_j, g_j; j \in [1, n-1]$

By defined function ℓ the vertices are labeled as

$$\begin{aligned} \ell(a_j) &= 5j - 5 + k / j \text{ in } [1, n] \\ \ell(b_j) &= 5j - 4 + k / j \text{ in } [1, n] \\ \ell(f_j) &= 5j - 3 + k / j \text{ in } [1, n] \\ \ell(g_j) &= 5j - 2 + k / j \text{ in } [1, n] \end{aligned}$$

The edges are labeled as

$$\begin{aligned} \ell(a_j b_j) &= 5j - 5 + k / j \text{ in } [1, n] \\ \ell(a_j f_j) &= 5j - 4 + k / j \text{ in } [1, n-1] \\ \ell(f_j a_{j+1}) &= 5j - 2 + k / j \text{ in } [1, n-1] \\ \ell(b_j g_j) &= 5j - 3 + k / j \text{ in } [1, n-1] \\ \ell(g_j b_{j+1}) &= 5j - 1 + k / j \text{ in } [1, n] \end{aligned}$$

Therefore, ℓ is obviously satisfied k - HML.

Case (2):

A subdivision of a Ladder $L_n = P_n \times K_2$ is obtained by subdividing each and every edge $a_j b_j$ of $L_n = P_n \times K_2$

On subdividing each and every edge $a_j b_j$ we obtain a new vertex $h_j; j \in [1, n]$ By defined function ℓ the vertices are labeled as





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$$\begin{aligned} \ell(a_j) &= 4j - 4 + k / j \text{ in } [1, n] \\ \ell(b_j) &= 4j - 2 + k / j \text{ in } [1, n] \\ \ell(h_j) &= 4j - 3 + k / j \text{ in } [1, n] \end{aligned}$$

The edges are labeled as

$$\begin{aligned} \ell(a_j a_{j+1}) &= 4j - 2 + k / j \text{ in } [1, n - 1] \\ \ell(b_j b_{j+1}) &= 4j - 1 + k / j \text{ in } [1, n - 1] \\ \ell(a_j h_j) &= 4j - 4 + k / j \text{ in } [1, n] \\ \ell(h_j b_j) &= 4j - 3 + k / j \text{ in } [1, n] \end{aligned}$$

Therefore, ℓ is obviously satisfied k - HML.

Case (3):

A subdivision of a Ladder $L_n = P_n \times K_2$ is obtained by subdividing each and every edges of $L_n = P_n \times K_2$

On subdividing each and every edges $a_j a_{j+1}$ and $b_j b_{j+1}$ we obtain a new vertices $f_j, g_j ; j \in [1, n - 1]$

On subdividing each and every edges $a_j b_j$ we obtain a new vertex $h_j ; j \in [1, n]$ By defined function ℓ the vertices are labeled as

$$\begin{aligned} \ell(a_j) &= 6j - 6 + k / j \text{ in } [1, n] \\ \ell(b_j) &= 6j - 4 + k / j \text{ in } [1, n] \\ \ell(f_j) &= 6j - 3 + k / j \text{ in } [1, n - 1] \\ \ell(g_j) &= 6j - 2 + k / j \text{ in } [1, n - 1] \\ \ell(h_j) &= 6j - 5 + k / j \text{ in } [1, n] \end{aligned}$$

The edges are labeled as

$$\begin{aligned} \ell(a_j h_j) &= 6j - 6 + k / j \text{ in } [1, n] \\ \ell(h_j a_j) &= 6j - 5 + k / j \text{ in } [1, n] \\ \ell(a_j f_j) &= 6j - 4 + k / j \text{ in } [1, n - 1] \\ \ell(f_j a_{j+1}) &= 6j - 2 + k / j \text{ in } [1, n - 1] \\ \ell(b_j g_j) &= 6j - 3 + k / j \text{ in } [1, n - 1] \\ \ell(g_j b_{j+1}) &= 6j - 1 + k / j \text{ in } [1, n - 1] \end{aligned}$$

Therefore, ℓ is obviously satisfied k - HML.





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Hence, we can conclude that the graph $G = S(L_n = P_n \times K_2)$ is a k - HMLG by the beyond cases.

Example 2.2: The subdivision of k - HML of the Ladder $L_4 = P_4 \times K_2$ is given in the Fig:2.4,2.5 & 2.6

Theorem 2.3:

Each Triangular Snake's (T_n) subdivision is k - HMG

Proof:

Triangular Snake T_n is establishes the boundaries by linking each pair of vertices of a distinct open walk to a new vertex. To reconstruct each edge of an open walk with separate vertices, a cyclic graph C_3 with $2n + 1$ vertices and $3n$ edges can be employed

A graph $G = S(T_n)$ obtain by subdividing each and every edges of T_n

A mapping or function $\ell: V \rightarrow \{k + 0, k + 1, k + 2, k + 3, \dots, k + m\}$ is defined and consider for the subsequent scenarios

Case (1):

A subdivision of a Triangular Snake T_n is obtained by subdividing each and every edge $a_j a_{j+1}$ of T_n

On subdividing each and every edge $a_j a_{j+1}$ we obtain new vertices $f_j; j \in [1, n - 1]$

By defined function ℓ the vertices are labeled as

$$\ell(a_j) = 4j - 4 + k / j \text{ in } [1, n]$$

$$\ell(b_j) = 4j - 3 + k / j \text{ in } [1, n - 1]$$

$$\ell(f_j) = 4j - 1 + k / j \text{ in } [1, n - 1]$$

The edges are labeled as

$$\ell(a_j b_j) = 4j - 4 + k / j \text{ in } [1, n - 1]$$

$$\ell(a_{j+1} b_j) = 4j - 2 + k / j \text{ in } [1, n - 1]$$

$$\ell(a_j f_j) = 4j - 3 + k / j \text{ in } [1, n - 1]$$

$$\ell(f_j a_{j+1}) = 4j - 1 + k / j \text{ in } [1, n - 1]$$

Therefore, ℓ is obviously satisfied k - HML.

Case (2):

A subdivision of a Triangular Snake T_n is obtained by subdividing each and every edges $a_j b_j$ of T_n

On subdividing each and every edges $a_j b_j$ and $a_{j+1} b_j$ we obtain a new vertex $g_j, h_j; j \in [1, n - 1]$

By defined function ℓ the vertices are labeled as





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$$\ell(a_j) = 5j - 5 + k / j \text{ in } [1, n]$$

$$\ell(b_j) = 5j - 3 + k / j \text{ in } [1, n - 1]$$

$$\ell(g_j) = 5j - 4 + k / j \text{ in } [1, n - 1]$$

$$\ell(h_j) = 5j - 2 + k / j \text{ in } [1, n - 1]$$

The edges are labeled as

$$\ell(a_j a_{j+1}) = 5j - 3 + k / j \text{ in } [1, n - 1]$$

$$\ell(a_{j+1} g_j) = 5j - 5 + k / j \text{ in } [1, n - 1]$$

$$\ell(g_j b_j) = 5j - 4 + k / j \text{ in } [1, n - 1]$$

$$\ell(a_{j+1} h_j) = 5j - 1 + k / j \text{ in } [1, n - 1]$$

$$\ell(h_j b_j) = 5j - 2 + k / j \text{ in } [1, n - 1]$$

Therefore, ℓ is obviously satisfied k - HML.

Case (3):

A subdivision of a Triangular Snake T_n is obtained by subdividing each and every edges of T_n

On subdividing each and every edges $a_j b_j$ and $a_{j+1} b_j$ we obtain a new vertices $g_j, h_j; j \in [1, n - 1]$

On subdividing each and every edges $a_j a_{j+1}$ we obtain a new vertex $f_j; j \in [1, n - 1]$ By defined function ℓ the vertices are labeled as

$$\ell(a_j) = 6j - 6 + k / j \text{ in } [1, n]$$

$$\ell(b_j) = 6j - 4 + k / j \text{ in } [1, n - 1]$$

$$\ell(f_j) = 6j - 1 + k / j \text{ in } [1, n - 1]$$

$$\ell(g_j) = 6j - 5 + k / j \text{ in } [1, n - 1]$$

$$\ell(h_j) = 6j - 3 + k / j \text{ in } [1, n - 1]$$

The edges bear labels

$$\ell(a_j f_j) = 6j - 4 + k / j \text{ in } [1, n - 1]$$

$$\ell(f_j a_{j+1}) = 6j - 1 + k / j \text{ in } [1, n - 1]$$

$$\ell(a_j g_j) = 6j - 6 + k / j \text{ in } [1, n]$$

$$\ell(g_j b_j) = 6j - 5 + k / j \text{ in } [1, n - 1]$$

$$\ell(a_{j+1} h_j) = 6j - 2 + k / j \text{ in } [1, n]$$

$$\ell(h_j b_j) = 6j - 3 + k / j \text{ in } [1, n - 1]$$

Therefore, ℓ is obviously satisfied k - HML.





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Based on the preceding situations, we may deduce that the graph $G=S(T_n)$ is a k Heronian Mean Labeling Graph.

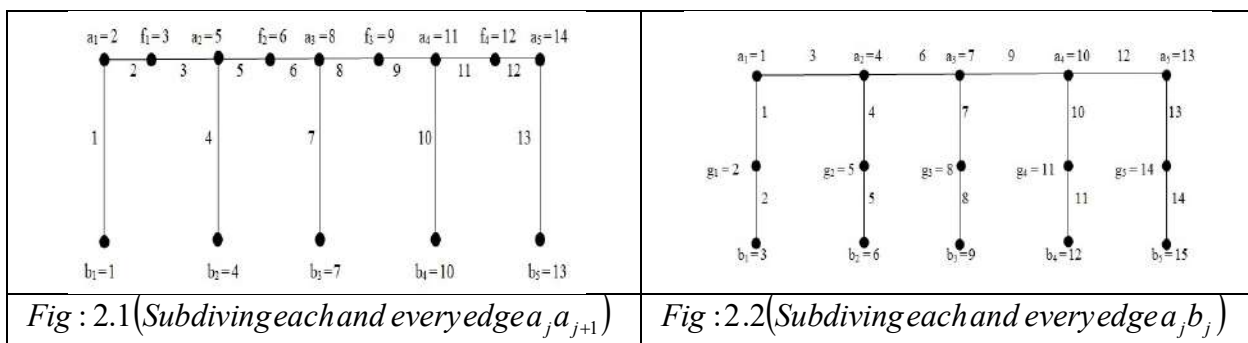
Example 2.3: The splitting of k - HML of the Triangular Snake T_4 is given in the Fig:2.7,2.8 & 2.9

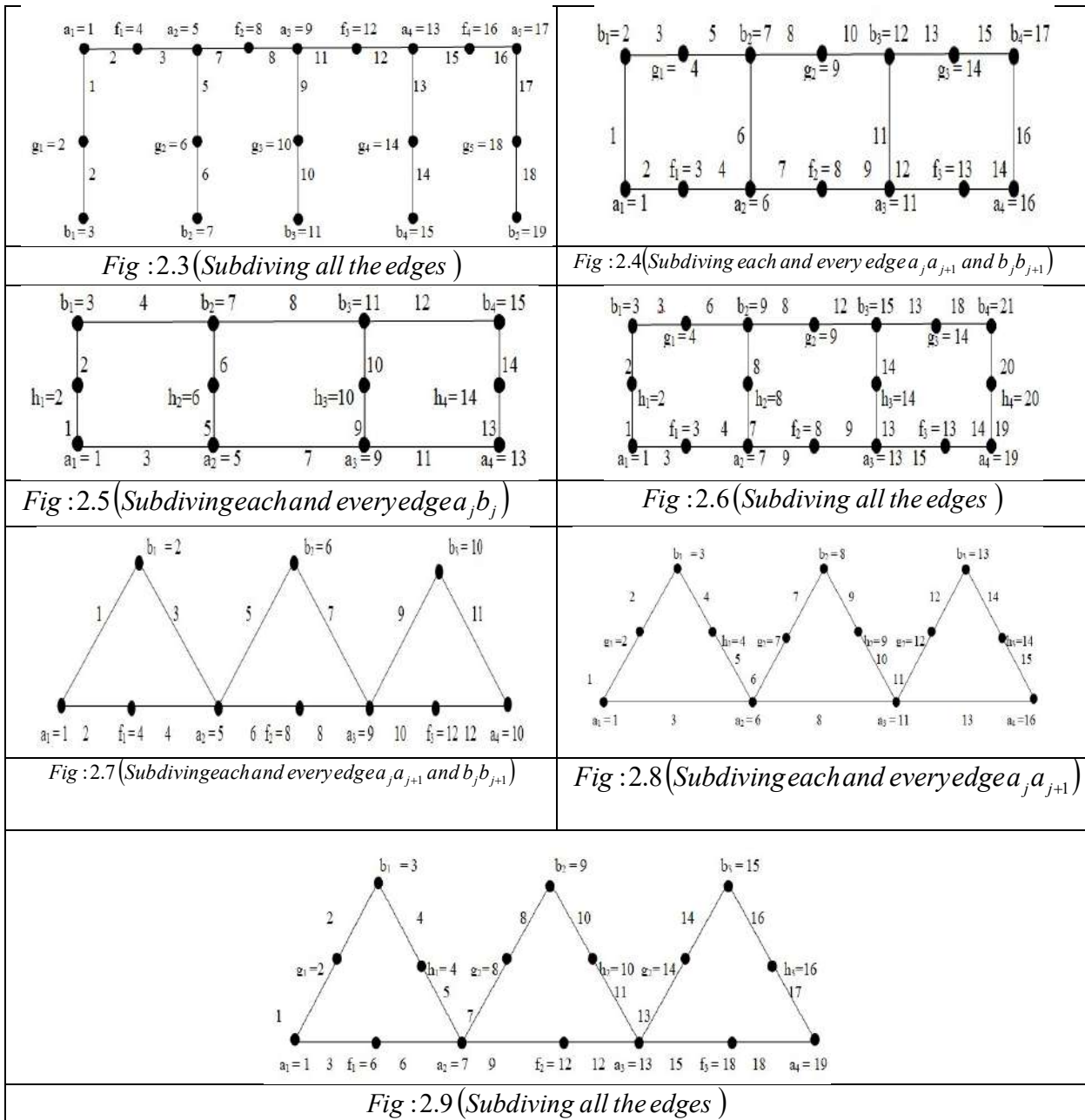
CONCLUSION

In this article, we have shown the subdivision of the k - HML and demonstrated its acceptance on a few graphs. This article’s future scope can be expanded by using other graph families.

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Bio-Convective Hybrid Stagnation-Point Flow Due to Induced Magnetic Field

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ABSTRACT

Magnetite nanoparticles with varying surface coverages are highly sought after for several applications due to their inherent magnetic characteristics, nanometer-scale dimensions, and well-defined surface shape. Magnetite nanoparticles are extensively utilized in various medicinal and biological applications; however, their utilization in optics is less prevalent. The study investigates the movement of water carrying magnetite Nano-particles, and single-walled carbon nanotube (SWCNT) in a flow with a stagnation position along stretching sheets. The effects of viscous dissipation, induced magnetic fields, stratification, and chemical reaction are considered. The numerical analysis is performed with the Runge-Kutta-Fehlberg technique in correlation with the firing methodology.

Keywords: Nanofluids, Magnetite Nanoparticles, Bioconvective, Magnetic field, Runge-Kutta-Fehlberg, SWCNT.

INTRODUCTION

The study of Nano fluids that involve microorganisms is a rapidly emerging field of research that has attracted scientists due to the significance of this field in the creation of biofuels, the elimination of toxins, the precise delivery of medicines, and the digesting of food. In order to highlight the impact that effective parameters have on flow profiles and physical quantities, graphs are utilized. This paper key objectives are to accomplish the following:



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- Develop a bio-convective model to study the behavior of magnetite nanoparticles and SWCNTs in water. Consider the effects of temperature stratification, induced magnetic fields, viscosity dissipation, solutal stratification, motile density stratification, and chemical reaction.
- The purpose of this paper is to provide theoretical understanding regarding the effective parameters and their consequences on flow profiles.
- Investigate the significance of relevant factors with regard to surface drag, mass transfer rate, heat transfer rate, and the quantity of microorganisms per unit area.

RELATED WORK

A nanofluid with a magnetic field is a stable colloidal suspension that consists of a base solution, single-domain magnetic particles, and a surfactant. The stability of the magnetic fluid is determined by the repulsion caused by the surfactant and the motion of Brownian particles. Additionally, the resistance of magnetic particles to gravity sedimentation also contributes to the stability. Heat transfer and thermal management and have gained significant interest due to its use in electronics devices, industrial applications, and thermal systems. Shi et al. evaluated the viscosity, thermal conductivity, and specific heat capacity of the magnetic Fe₃O₄@CNT nanocomposites. The experimental demonstration showcased the recyclability, magnetic responsiveness, and adjustability of heat transfer. The magnetic Nano fluid was generated using the hydrothermal process and the thermophysical features of the Nano fluid, which relied on temperature. These findings were detailed in detail. The study considered the effects of viscous dissipation, heat generation/absorption, and thermal radiation. Khan¹⁴ provides an explanation of the combined influence of electric field and magnetohydrodynamics on the unsteady flow of Maxwell's Nano fluid over a stretching surface, taking into account the effects of thermal radiation and changing heat. The heat exchange efficiencies of a suspension of magnetic nanoparticles, known as magnetic nanofluid, under original convection can be modified by altering the direction, shape, and intensity of the magnetic field. This is possible since magnetic nanofluids possess exceptional magnetic characteristics. Nevertheless, the thermal conductivities of magnetic nanoparticles is lower compared to nano-particles such as CuO and Al₂O₃. This limitation restricts their extensive use, especially in the energy industry and heat exchangers. Therefore, nano-composites that possess both magnetic properties and increased thermal conductivity are an ideal option for significantly enhancing the efficiency of heat exchange by natural convection, surpassing other materials in this regard. Provides a comprehensive analysis of the convective heat transfer properties of Nano fluid in a straight tube, with a focus on its magneto controllable behavior.

METHODOLOGY: MATHEMATICAL FRAME

An incompressible fluid's flow across a linearly extending sheet is the subject of the investigation. The flow is steady and occurs in two dimensions. These assumptions are illustrated in Figure 1.

- The x-axis is tangential to expanding sheet, and the area where the y-value is greater than zero is filled with a water based Fe₃O₄ nanofluid derived from SWCNT.
- $U_w(x) = cx$ and $U_e(x) = ax$ These numbers stand for the free stream velocity and the thickness of the expanding sheet.
- The induced magnetic field vector, denoted as $H = (H_1, H_2)$, is defined so that H₁ represents the magnetic component along the x-direction and H₂ represents the magnetic component along the y-direction.
- The consequences of viscosity dissipation and chemical reaction are considered into the design.
- Solutal slide, motile density, and thermal impacts are taken into account. with respect to the boundary conditions (Z. Iqbal et al., 2017, Alsaedi et al., 2017);





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$$u = U_W(x) = cx, v = 0, \frac{\partial H_1}{\partial y} = H_2 = 0, T = T_W = T_0 + \delta_1 x, \\ C = C_W = C_0 + \epsilon_1 x, N = N_W = N_0 + \xi_1 x \quad \text{at } y = 0$$

$$u \rightarrow U_e(x) = ax, H_1 \rightarrow H_e(x) = H_0 x, T \rightarrow T_\infty = T_0 + \delta_2 x, \\ C \rightarrow C_\infty = C_0 + \epsilon_2 x, N \rightarrow N_\infty = N_0 + \xi_2 x \quad \text{as } y \rightarrow \infty$$

Where,

$$\alpha_m = \frac{1}{4\pi\mu_e\sigma_{nf}}$$

stands for the magnetic diffusivity

Take into consideration the following transformations of similarity: (Z. Iqbal et al.,2017; Alsaedi et al., 2017):

$$u = cx f'(\zeta), v = -\sqrt{c\vartheta} f(\zeta), H_1 = H_0 x g'(\zeta), \zeta = y\sqrt{\frac{c}{\vartheta}}, H_2 = -H_0\sqrt{\frac{\vartheta}{c}} g(\zeta), \\ \theta(\zeta) = \frac{T - T_\infty}{T_W - T_0}, \psi(\zeta) = \frac{C - C_\infty}{C_W - C_0}, \chi(\zeta) = \frac{N - N_\infty}{N_W - N_0}$$

Employing the similarity transformations into Equations , we get:

$$f''' - A_1 A_2 \left\{ (f')^2 - f f'' - \frac{\beta}{A_2} \left\{ (g')^2 - g g'' - 1 \right\} - A^2 \right\} = 0$$

$$g''' - \frac{A_5}{\lambda} \{ g f'' - f g'' \} = 0$$

$$\theta'' + \frac{A_3 Pr}{A_4} f \theta' + \frac{Ec Pr}{A_1 A_4} (f'')^2 = 0$$

$$\psi'' + Le f \psi' - Kr Le \psi = 0$$

$$\chi'' + Lb f \chi' - Pe \{ (\chi + \Omega) \psi'' + \chi' \psi' \} = 0$$

subject to the boundary conditions

$$f(\zeta) = 0, f'(\zeta) = 1, g(\zeta) = 0, g''(\zeta) = 0, \theta(\zeta) = 1 - S_1, \\ \psi(\zeta) = 1 - S_2, \chi(\zeta) = 1 - S_3 \quad \text{when } \zeta = 0$$

$$f'(\zeta) \rightarrow A, g'(\zeta) \rightarrow 1, \theta(\zeta) \rightarrow 0, \\ \psi(\zeta) \rightarrow 0, \chi(\zeta) \rightarrow 0 \quad \text{as } \zeta \rightarrow \infty$$





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The hybrid nanofluid models incorporated are (Mabood, Ashwinkumar, & Sandeep, 2022; Sreedevi & Reddy, 2019):

$$\frac{\mu_{hnf}}{\mu_f} = \frac{1}{(1 - \phi_{Fe_3O_4})^{2.5} (1 - \phi_{SWCNT})^{2.5}} = \frac{1}{A_1}$$

$$\frac{\rho_{hnf}}{\rho_f} = (1 - \phi_{SWCNT}) \left\{ (1 - \phi_{Fe_3O_4}) + \frac{\rho_{Fe_3O_4}}{\rho_f} \phi_{Fe_3O_4} \right\} + \frac{\rho_{SWCNT}}{\rho_f} \phi_{SWCNT} = A_2$$

$$\begin{aligned} \frac{(\rho C_p)_{hnf}}{(\rho C_p)_f} &= (1 - \phi_{SWCNT}) \left\{ (1 - \phi_{Fe_3O_4}) + \frac{(\rho C_p)_{Fe_3O_4}}{(\rho C_p)_f} \phi_{Fe_3O_4} \right\} \\ &+ \frac{(\rho C_p)_{SWCNT}}{(\rho C_p)_f} \phi_{SWCNT} = A_3 \end{aligned}$$

$$\frac{k_{hnf}}{k_{bf}} = \frac{1 - \phi_{SWCNT} + 2\phi_{SWCNT} \left(\frac{k_{SWCNT}}{k_{SWCNT} - k_{bf}} \right) \ln \left(\frac{k_{SWCNT} + k_{bf}}{2k_{bf}} \right)}{1 - \phi_{SWCNT} + 2\phi_{SWCNT} \left(\frac{k_{bf}}{k_{SWCNT} - k_{bf}} \right) \ln \left(\frac{k_{SWCNT} + k_{bf}}{2k_{bf}} \right)}$$

$$\frac{k_{bf}}{k_f} = \frac{k_{Fe_3O_4} + 2k_f - 2\phi_{Fe_3O_4} (k_f - k_{Fe_3O_4})}{k_{Fe_3O_4} + 2k_f + \phi_{Fe_3O_4} (k_f - k_{Fe_3O_4})}$$

$$\frac{\sigma_{hnf}}{\sigma_f} = 1 + \frac{3 \left\{ \frac{\phi_{Fe_3O_4} \sigma_{Fe_3O_4} + \phi_{SWCNT} \sigma_{SWCNT}}{\sigma_f} - (\phi_{Fe_3O_4} + \phi_{SWCNT}) \right\}}{2 + \left\{ \frac{\phi_{Fe_3O_4} \sigma_{Fe_3O_4} + \phi_{SWCNT} \sigma_{SWCNT}}{(\phi_{Fe_3O_4} + \phi_{SWCNT}) \sigma_f} \right\} - \left\{ \frac{\phi_{Fe_3O_4} \sigma_{Fe_3O_4} + \phi_{SWCNT} \sigma_{SWCNT}}{\sigma_f} - (\phi_{Fe_3O_4} + \phi_{SWCNT}) \right\}}$$

$$A_4 = \frac{k_{hnf}}{k_f} = \frac{k_{hnf}}{k_{bf}} \times \frac{k_{bf}}{k_f}, \text{ and } A_5 = \frac{\sigma_{hnf}}{\sigma_f}$$

The nanofluid models incorporated are (Sreedevi & Reddy, 2019; Iqbal et al., 2017):

Drag Coefficient:

$$Cf_x = \frac{\tau_w}{\rho_f (U_w)^2} = \frac{\mu_{hnf}}{\rho_f} \frac{\partial u}{\partial y} \Big|_{y=0} (U_w)^{-2}$$

$$\Rightarrow Cf_x Re_x^{1/2} = \frac{f''(0)}{A_1}$$

Nusselt number:





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$$Nu_x = \frac{x q_w}{k_f (T_w - T_0)} = \frac{-x k_{hnf} \frac{\partial T}{\partial y} \Big|_{y=0}}{k_f (T_w - T_0)}$$

$$\Rightarrow Nu_x Re_x^{-1/2} = -A_4 \theta'(0)$$

Sherwood number:

$$Sh_x = \frac{x q_m}{D_B (C_w - C_0)} = \frac{-x D_B \frac{\partial C}{\partial y} \Big|_{y=0}}{D_B (C_w - C_0)}$$

$$\Rightarrow Sh_x Re_x^{-1/2} = -\psi'(0)$$

Motile density quantity:

$$Nn_x = \frac{x q_n}{D_m (N_w - N_0)} = \frac{-x D_m \frac{\partial N}{\partial y} \Big|_{y=0}}{D_m (N_w - N_0)}$$

$$\Rightarrow Nn_x Re_x^{-1/2} = -\chi'(0)$$

Where,

$$Re_x = \frac{xU_w}{\nu_f}$$

is the Reynold's quantity.

RESULTS: NUMERICAL FRAME & VALIDATION

Given the nonlinear nature of the equations in conjunction with the boundary conditions, it is challenging to obtain an exact solution or closed-form to the challenge at hand. This is why numerical approaches, namely the Runge-Kutta-Fehlberg technique in combination with the shoot-ing methodology, are used to get the approximations. This can be accomplished by first assuming the following assumption:

$$\begin{aligned} \Gamma_1 &= f, & \Gamma_2 &= f', & \Gamma_3 &= f'', & \Gamma_3' &= f''', & \Gamma_4 &= g, & \Gamma_5 &= g', \\ \Gamma_6 &= g'', & \Gamma_6' &= g''', & \Gamma_7 &= \theta, & \Gamma_8 &= \theta', & \Gamma_8' &= \theta'', & \Gamma_9 &= \psi, \\ \Gamma_{10} &= \psi', & \Gamma_{10}' &= \psi'', & \Gamma_{11} &= \chi, & \Gamma_{12} &= \chi', & \Gamma_{12}' &= \chi'' \end{aligned}$$

Presented below is the reduced version of the first-order conventional differential equation:





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$$\Upsilon_1' = \Upsilon_2, \Upsilon_2' = \Upsilon_3,$$

$$\Upsilon_3' = A_1 A_2 \left\{ (\Upsilon_2)^2 - \Upsilon_1 \Upsilon_3 - \frac{\beta}{A_2} \{ (\Upsilon_5)^2 - \Upsilon_4 \Upsilon_6 - 1 \} - A^2 \right\},$$

$$\Upsilon_4' = \Upsilon_5, \Upsilon_5' = \Upsilon_6,$$

$$\Upsilon_6' = \frac{A_5}{\lambda} \{ \Upsilon_4 \Upsilon_3 - \Upsilon_1 \Upsilon_6 \},$$

$$\Upsilon_7' = \Upsilon_8, \Upsilon_8' = - \left\{ \frac{A_3 Pr}{A_4} \Upsilon_1 \Upsilon_8 + \frac{Ec Pr}{A_1 A_4} (\Upsilon_3)^2 \right\},$$

$$\Upsilon_9' = \Upsilon_{10}, \Upsilon_{10}' = Kr Le \Upsilon_9 - Le \Upsilon_1 \Upsilon_{10},$$

$$\Upsilon_{11}' = \Upsilon_{12}, \Upsilon_{12}' = Pe \{ (\Upsilon_{11} + \Omega) \Upsilon_{10}' + \Upsilon_{12} \Upsilon_{10} \} - Lb \Upsilon_1 \Upsilon_{12}.$$

Having

$$\Upsilon_1(0) = 0, \quad \Upsilon_2(0) = 1, \quad \Upsilon_3(0) = \Gamma_1, \quad \Upsilon_4(0) = 0,$$

$$\Upsilon_5(0) = \Gamma_2, \quad \Upsilon_6(0) = 0, \quad \Upsilon_7(0) = 1 - S_1, \quad \Upsilon_8(0) = \Gamma_3,$$

$$\Upsilon_9(0) = 1 - S_2, \quad \Upsilon_{10}(0) = \Gamma_4, \quad \Upsilon_{11}(0) = 1 - S_3, \quad \Upsilon_{12}(0) = \Gamma_5$$

The values of $\Lambda_1, \Lambda_2, \Lambda_3,$ and Λ_4 are calculated using the Newton Raphson technique, starting with an appropriate initial assumption. The validity of the current problem and accuracy of have been ensured by doing a thorough comparison between the work that is currently being done and studies that have been published in the past. By comparing this study closely to previous publications by Hayat et al. (2015), Iqbal et al. (2016), and Azhar et al. (2017), we were able to determine that the code is genuine and that our research is well-grounded (Table 1). The effects of relevant parameters on the profiles of microbiological concentration ($\chi(\zeta)$), induced magnetic field ($g'(\zeta)$), concentrations ($\psi(\zeta)$), temperatures ($\theta(\zeta)$), and velocity ($f'(\zeta)$), are seen. Experiments have been conducted on a hybrid nano-fluid consisting of water-based Fe3O4 and SWCNT, as well as a nano-fluid containing only Fe3O4. The Prandtl number (Pr) for the hybrid nano-fluid was fixed at 6.3, while the Prandtl number for the Fe3O4 nano-fluid was fixed at 10.1. The thermo-physical characteristics of water, SWCNT (nano-particle 2), and Fe3O4 (nano-particle 1) are presented in Table 2. The study investigates the movement of water carrying magnetite nano-particles, and SWCNT in a flow with a stagnation point along a stretching sheet. The effects of viscous dissipation, induced magnetic field, stratification, and chemical reaction are considered. The numerical analysis is performed with the Runge-Kutta-Fehlberg technique in conjunction with firing methodology. The primary findings of the study can be summarized below:

- The increase in the proportion of nano-particles, and SWCNT results in a rise in the temperature of the nanofluid. Moreover, increasing the Eckert quantity enhances the temperature of the nanofluid. The rise in nanofluid temperature resulting from the relevant factors has a positive effect on the destruction of tumors and cancer cells.



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- The velocity profile exhibits a direct proportionality to the magnetic parameter when A is less than 1, and an inverse proportionality when A is more than 1.
- The highest drag coefficient occurs when the magnetic parameter is at higher levels and the volume fraction of nano-particles, and SWCNT is smaller, with $A = 0.8$. Nevertheless, the highest drag coefficient (at $A = 1.2$) occurs when the magnetic parameter is smaller and the volume fraction of nano-particles, and SWCNT is larger. From a biological standpoint, a higher drag coefficient indicates a greater level of interaction between the surface and the fluid. This interaction is advantageous in the context of biomedical imaging and targeted medication delivery.
- The rate at which mass are transferred decreases as the solutal stratification parameter increases, and increases as the reaction of chemical parameter increases.
- Increasing the reaction of chemical parameter has a detrimental impact on the concentration profile, which in turn improves biomedical imaging, and medication.
- When the nanoparticle volume percentage, Eckert number, and thermal stratification parameter of a SWCNT are all reduced, the highest heat transfer rate is seen.

CONCLUSION

The augmentation of the ratio of nano-particles, specifically single-walled carbon nanotubes (SWCNT), leads to an elevation in the temperature of the nanofluid and it can be seen that the profile of velocity is directly in proportion to the magnetic parameters when A is less than 1, and inversely proportional when A is more than 1. From the research, it can be seen that a higher drag coefficient is present and it signifies a heightened degree of interaction between the surface and the fluid. This relationship is beneficial in the context of biomedical imaging and targeted medicine delivery.

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Table:1 Comparison of drag coefficient for different A values of Iqbal, Azhar, et al., 2017 and Hayat et al., 2015, 2016 when $\lambda = \beta = 0$

A	$Cf_x Re_x^{1/2}$		
	Iqbal et al., 2017	Hayat et al., 2015	Hayat et al., 2016
0.1	-0.969386	-0.96939	-0.96937
0.2	-0.918107	-0.91811	-0.91813
0.5	-0.667263	-0.66726	-0.66723
0.7	-0.433475	-0.43346	-0.43345
0.8	-0.299388	-0.29929	-0.29921
0.9	-0.154716	-0.15458	-0.1545471
1	0	0	0

Table:2 Thermo-physical properties of SWCNT, Fe₃O₄ and water

Property	Water	Fe ₃ O ₄	SWCNT
	<i>(conventional fluid)</i>	<i>(nanoparticle 1)</i>	<i>(nanoparticle 2)</i>
ρ	997	5180	2600
C_p	4179	670	425
k	0.613	9.7	6600
σ	0.05	25000	10 ⁶





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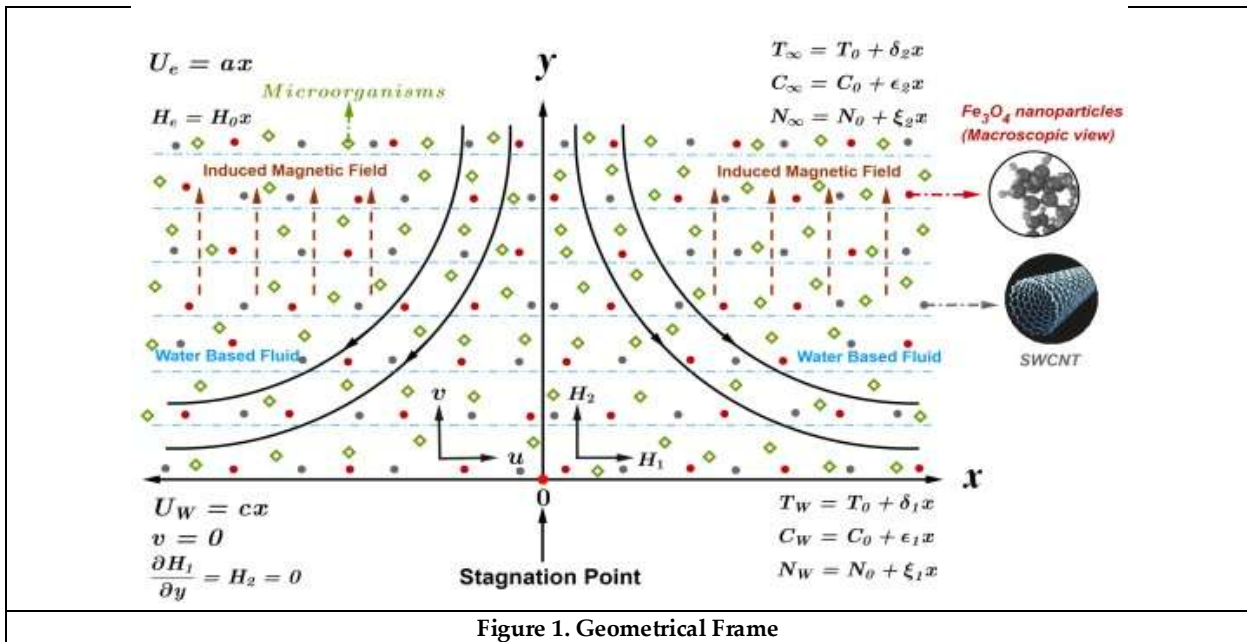


Figure 1. Geometrical Frame





A Decision Making Problem for Interval Valued Neutrosophic Soft Multisets Using TOPSIS Method

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ABSTRACT

In this paper, we introduce certain distance and similarity measures for Interval valued neutrosophic soft multisets with their fundamental properties and examples. Furthermore, we construct a TOPSIS algorithm using one of the proposed distance measures for Interval valued neutrosophic soft multisets. To demonstrate the significance and sufficiency of the proposed TOPSIS algorithm, we apply it for a decision making problem and determined an optimal solution.

Keywords: Distance measure, Similarity measure, Interval valued neutrosophic soft multisets (IVNSMS), TOPSIS.

INTRODUCTION

Lotfi A. Zadeh proposed fuzzy sets (FS)[1] to administ objects which has fuzziness as their property and not belong to crisp sets. Meanwhile, fuzzy sets only have membership function to manage objects. To overcome this intuitionistic fuzzy sets (IFS)[2]were introduced with membership and non-membership functions. Later it was extended to the interval valued intuitionistic fuzzy sets[3] by using intervals as membership functions. F. Smarandache[4] introduced neutrosophic sets with indeterminacy membership function as a generalization of intuitionistic fuzzy set theory to deal inaccurate information. Wang et al. [5]introduced interval valued neutrosophic sets as an extension of neutrosophic sets which is more practical and flexible than neutrosophic sets. In 1999, Molodtsov[6] proposed thoroughly a new mathematical approach called soft sets, apart from fuzzy sets, for





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modelling objects with uncertainty character. Soft matrices and operations on soft matrices were presented by Çağman-Enginoğlu[7]. Hybrid structures of soft sets like fuzzy soft sets[8], intuitionistic fuzzy soft sets[9] and interval valued intuitionistic fuzzy soft sets[10] were introduced. P.K. Maji [11] established neutrosophic soft sets by incorporating neutrosophic sets with soft sets and made them widely useful in indeterminate and imprecise environment. Later, I. Deli[12] extended neutrosophic soft sets to interval valued neutrosophic soft sets by combining interval valued neutrosophic sets and soft sets. Alkhazaleh et al.[13] proposed soft multisets as an expansion of soft sets in multiple dimensions. Some operations of soft multisets were dealt by several researchers ([14], [15], [16], [17]). Later, Alkhazaleh and Salleh[18] defined fuzzy soft multisets and presented a decision making algorithm to solve an application of fuzzy soft multisets. Further, I. Deli et al.[19] introduced neutrosophic soft multisets by putting together the concepts of neutrosophic sets and soft multisets. A. Al-Quran & N. Hassan[20] and C. Granados et al.[21] defined other hybrid structures like neutrosophic vague soft multisets and weighted neutrosophic soft multisets respectively. In the study of problem solving, there is a necessity to compare two sets. Several researchers have studied the distance and similarity between fuzzy sets, interval valued fuzzy sets, neutrosophic sets, interval valued neutrosophic sets, soft sets, intuitionistic fuzzy soft sets and neutrosophic soft sets. S. Broumi et al.[22] introduced distance and similarity measures of interval valued neutrosophic soft sets with their necessary properties. A. Mukherjee et al.[23] defined some similarity measures of interval valued neutrosophic soft sets and employed it in the application of pattern recognition problems. TOPSIS (Technique for Order Performance by Similarity to Ideal Solution) is one of the most primary methods in decision making which is defined by Hwang and Yoon[24]. The TOPSIS method provides the most appropriate solutions based on its main idea that, the best result should have the briefest distance from PIS (Positive Ideal Solution) and the utmost distance from NIS (Negative Ideal Solution). The TOPSIS method for the group decision making problem was extended by Chen[25], in which the weights of criteria are represented by linguistic variables. S. Saghaian and S.R. Hejazi[26] introduced a TOPSIS method which employs distance measure to find an optimal decision. Ashtiani et al.[27] considered interval numbers as linguistic variables and proposed a new method called interval valued fuzzy TOPSIS method. Jin et al.[28] expanded TOPSIS method to MADM by considering intuitionistic fuzzy sets as attribute values. Verma et al. [29] presented an interval valued intuitionistic fuzzy TOPSIS method and applied it to a facility location problem. Pingping Chi and Peide Liu[30] extended TOPSIS to interval neutrosophic sets by utilizing distance measures of Interval neutrosophic sets. The Interval valued neutrosophic soft multisets (IVNSMS)[31] can effortlessly characterize the incomplete, inconsistent and indeterminate information about objects in multiple universes. In this paper, we introduce the distance and similarity measures between IVNSMS and discuss some properties of distance and similarities. In addition, we establish the TOPSIS algorithm by using one of the proposed distance measures and apply it to a personal selection problem and determine the results.

PRELIMINARIES

Definition 2.1.[4] Let U be a space of points (objects), with a generic element in U denoted by u . A neutrosophic set A in U is characterized by a truth-membership function T_A , an indeterminacy-membership function I_A and a falsity-membership function F_A . $T_A(u)$; $I_A(u)$ and $F_A(u)$ are real standard or nonstandard subsets of $[0, 1]$. There is no restriction on the sum of $T_A(u)$; $I_A(u)$ and $F_A(u)$, so $0 \leq \sup T_A(u) + \sup I_A(u) + \sup F_A(u) \leq 3$.

Definition 2.2.[5] Let U be a space of points (objects), with a generic element in U denoted by u . An interval valued neutrosophic set (IVN-set) A in U is characterized by truth-membership function T_A , an indeterminacy-membership function I_A and a falsity-membership function F_A . For each point $u \in U$; T_A , I_A and $F_A \subseteq [0, 1]$. Thus, an IVN-set over U can be represented by the set $A = \{(T_A(u), I_A(u), F_A(u)) / u: u \in U\}$.

Here, $(T_A(u), I_A(u), F_A(u))$ is called interval valued neutrosophic number for all $u \in U$ and all interval valued neutrosophic numbers over U will be denoted by $IVN(U)$.





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Definition 2.3.[12] Let U be an initial universe set, $IVN(U)$ denotes the set of all interval valued neutrosophic sets of U and E be a set of parameters that describe the elements of U . An interval valued neutrosophic soft sets over U is a set defined by a set valued function Y_K representing a mapping $v_K: E \rightarrow IVN(U)$.

It can be written as a set of ordered pairs

$$Y_K = \{ (x, v_K(x)) : x \in E \}.$$

Here, an interval valued neutrosophic set v_K is called approximate function of the interval valued neutrosophic (ivn)-soft sets Y_K . And $v_K(x)$ is called x-approximate value of $x \in E$.

Definition 2.4.[12] Let $Y_K \in IVNS(U)$. Based on Y_K , we can define an Interval valued neutrosophic set $\langle \alpha, \beta, \gamma \rangle_{(Y_K)}^{avg} : A \rightarrow IVN(U)$ by

$$\langle \alpha, \beta, \gamma \rangle_{(Y_K)}^{avg}(x_i) = \sum_{u \in U} v_{K(x_i)}(u) / |U| \quad \text{for all } x \in E.$$

The interval valued neutrosophic set $\langle \alpha, \beta, \gamma \rangle_{(Y_K)}^{avg}$ is called the avg-threshold of the ivn-soft set Y_K .

Definition 2.5.[32] Let $x = ([T^L, T^U], [I^L, I^U], [F^L, F^U])$ be an Interval neutrosophic number and the score function $S(x)$ of an Interval neutrosophic number can be defined as follows:

$$S(x) = \frac{T^L + T^U}{2} + 1 - \frac{I^L + I^U}{2} + 1 - \frac{F^L + F^U}{2}.$$

Definition 2.6.[13] Let $\{U_i : i \in I\}$ be a collection of universes such that $\cap_{i \in I} U_i = \emptyset$ and let $\{E_{U_i} : i \in I\}$ be a collection of sets of parameters, $U = \prod_{i \in I} P(U_i)$ where $P(U_i)$ denotes the powerset of U_i , $E = \prod_{i \in I} E_{U_i}$ and $A \subseteq E$.

A pair (I, A) is called a soft multiset over U given by the mapping $I: A \rightarrow U$.

Definition 2.7.[31] Let $\{U_i : i \in I\}$ be a collection of universes such that $\cap_{i \in I} U_i = \emptyset$ and let $\{E_{U_i} : i \in I\}$ be a collection of sets of parameters, $U = \prod_{i \in I} IVN(U_i)$ where $IVN(U_i)$ denotes the set of all Interval valued neutrosophic sets of U_i , $E = \prod_{i \in I} E_{U_i}$ and $A \subseteq E$. An Interval valued neutrosophic soft multiset (IVNSMS) over U is the pair (I, A) given by the mapping $I: A \rightarrow U$. It can be represented by,

$$(I, A) = \{ (a_k, \langle [\inf T_1(u), \sup T_1(u)], [\inf I_1(u), \sup I_1(u)], [\inf F_1(u), \sup F_1(u)] \rangle) : a_k \in A \subseteq E, u \in U \}.$$

DISTANCE AND SIMILARITY MEASURES BETWEEN INTERVAL VALUED NEUTROSOPHIC SOFT MULTISSETS (IVNSMS)

In this section, we define distance measures for IVNSMS, like Hamming distance, Normalized hamming distance, Euclidean distance and Normalized euclidean distance along with their axioms and example. Also, Similarity measures for IVNSMS corresponding to the proposed distance measures are constructed. S. Broumi et al.[22] proposed several distance measures, generalized weighted distance measures and similarity measures for Interval neutrosophic soft sets, which can be used in real life applications. We extend it to IVNSMS.

Throughout this paper, $\{U_i : i \in I\}$ be a collection of universes such that $\cap_{i \in I} U_i = \emptyset$, $\{E_{U_i} : i \in I\}$ be a collection of sets of parameters, $U = \prod_{i \in I} IVN(U_i)$ and $A \subseteq E = \prod_{i \in I} E_{U_i}$. Let $X=(I,A)$ and $Y=(J,A)$ be two IVNSMS

$$(I, A) = \{ (a_k, \langle [\inf T_1(u), \sup T_1(u)], [\inf I_1(u), \sup I_1(u)], [\inf F_1(u), \sup F_1(u)] \rangle) : a_k \in A \subseteq E, u \in U \}.$$

$$(J, A) = \{ (a_k, \langle [\inf T_j(u), \sup T_j(u)], [\inf I_j(u), \sup I_j(u)], [\inf F_j(u), \sup F_j(u)] \rangle) : a_k \in A \subseteq E, u \in U \}.$$

Definition 3.1.

Hamming Distance

$$d_H(X, Y) = \sum_{i=1}^m \left[\sum_{j=1}^{|U_i|} \sum_{k=1}^n \frac{1}{6} \left| \inf T_i(a_k)(u_{(i,j)}) - \inf T_j(a_k)(u_{(i,j)}) \right| + \left| \sup T_i(a_k)(u_{(i,j)}) - \sup T_j(a_k)(u_{(i,j)}) \right| + \left| \inf I_i(a_k)(u_{(i,j)}) - \inf I_j(a_k)(u_{(i,j)}) \right| + \left| \sup I_i(a_k)(u_{(i,j)}) - \sup I_j(a_k)(u_{(i,j)}) \right| + \left| \inf F_i(a_k)(u_{(i,j)}) - \inf F_j(a_k)(u_{(i,j)}) \right| + \left| \sup F_i(a_k)(u_{(i,j)}) - \sup F_j(a_k)(u_{(i,j)}) \right| \right],$$

where $|U_i|$ is no. of elements in the universe $U_i, i = 1, 2, \dots, m$ and $(u_{(i,j)})$ is j -th element of the universe U_i .





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Normalized Hamming Distance

$$d_{nH}(X, Y) = \sum_{i=1}^m \left[\sum_{j=1}^{|U_i|} \sum_{k=1}^n \frac{1}{6n|U_i|} \left| \inf T_I(a_k)(u_{(i,j)}) - \inf T_J(a_k)(u_{(i,j)}) \right| \right. \\ \left. + \left| \sup T_I(a_k)(u_{(i,j)}) - \sup T_J(a_k)(u_{(i,j)}) \right| \right. \\ \left. + \left| \inf I_I(a_k)(u_{(i,j)}) - \inf I_J(a_k)(u_{(i,j)}) \right| + \left| \sup I_I(a_k)(u_{(i,j)}) - \sup I_J(a_k)(u_{(i,j)}) \right| \right. \\ \left. + \left| \inf F_I(a_k)(u_{(i,j)}) - \inf F_J(a_k)(u_{(i,j)}) \right| \right. \\ \left. + \left| \sup F_I(a_k)(u_{(i,j)}) - \sup F_J(a_k)(u_{(i,j)}) \right| \right].$$

Euclidean Distance

$$d_E(X, Y) = \left(\sum_{i=1}^m \left[\sum_{j=1}^{|U_i|} \sum_{k=1}^n \frac{1}{6} \left| \inf T_I(a_k)(u_{(i,j)}) - \inf T_J(a_k)(u_{(i,j)}) \right|^2 + \left| \sup T_I(a_k)(u_{(i,j)}) - \sup T_J(a_k)(u_{(i,j)}) \right|^2 \right. \right. \\ \left. + \left| \inf I_I(a_k)(u_{(i,j)}) - \inf I_J(a_k)(u_{(i,j)}) \right|^2 + \left| \sup I_I(a_k)(u_{(i,j)}) - \sup I_J(a_k)(u_{(i,j)}) \right|^2 \right. \\ \left. + \left| \inf F_I(a_k)(u_{(i,j)}) - \inf F_J(a_k)(u_{(i,j)}) \right|^2 + \left| \sup F_I(a_k)(u_{(i,j)}) - \sup F_J(a_k)(u_{(i,j)}) \right|^2 \right] \right)^{\frac{1}{2}}.$$

Normalized Euclidean Distance

$$d_{nE}(X, Y) = \left(\sum_{i=1}^m \left[\sum_{j=1}^{|U_i|} \sum_{k=1}^n \frac{1}{6n|U_i|} \left| \inf T_I(a_k)(u_{(i,j)}) - \inf T_J(a_k)(u_{(i,j)}) \right|^2 + \left| \sup T_I(a_k)(u_{(i,j)}) - \sup T_J(a_k)(u_{(i,j)}) \right|^2 \right. \right. \\ \left. + \left| \inf I_I(a_k)(u_{(i,j)}) - \inf I_J(a_k)(u_{(i,j)}) \right|^2 + \left| \sup I_I(a_k)(u_{(i,j)}) - \sup I_J(a_k)(u_{(i,j)}) \right|^2 \right. \\ \left. + \left| \inf F_I(a_k)(u_{(i,j)}) - \inf F_J(a_k)(u_{(i,j)}) \right|^2 \right. \\ \left. + \left| \sup F_I(a_k)(u_{(i,j)}) - \sup F_J(a_k)(u_{(i,j)}) \right|^2 \right] \right)^{\frac{1}{2}}.$$

Proposition 3.2. Let $d(X, Y)$ be distance measure between two IVNSMS $X=(I,A)$ and $Y=(J,A)$. Then

1. $d(X, Y) \geq 0$.
2. $d(X, Y) = d(Y, X)$.
3. $d(X, Y) = 0$ if and only if $X=Y$.
4. $d(X, Y) + d(Y, Z) \geq d(X, Z)$.

Proof: The proof is straightforward from Definition 3.1.

Definition 3.3. A generalized weighted distance between X and Y is defined as, for

$$\lambda \geq 0, d_\lambda(X, Y) = \sum_{i=1}^m \left[\frac{1}{6} \sum_{j=1}^{|U_i|} \sum_{k=1}^n w_{(i,j)} \left| \inf T_I(a_k)(u_{(i,j)}) - \inf T_J(a_k)(u_{(i,j)}) \right|^\lambda + \left| \sup T_I(a_k)(u_{(i,j)}) - \sup T_J(a_k)(u_{(i,j)}) \right|^\lambda \right. \\ \left. + \left| \inf I_I(a_k)(u_{(i,j)}) - \inf I_J(a_k)(u_{(i,j)}) \right|^\lambda + \left| \sup I_I(a_k)(u_{(i,j)}) - \sup I_J(a_k)(u_{(i,j)}) \right|^\lambda \right. \\ \left. + \left| \inf F_I(a_k)(u_{(i,j)}) - \inf F_J(a_k)(u_{(i,j)}) \right|^\lambda + \left| \sup F_I(a_k)(u_{(i,j)}) - \sup F_J(a_k)(u_{(i,j)}) \right|^\lambda \right]^{\frac{1}{\lambda}}, \tag{1}$$

and the Normalized generalized weighted distance is defined as





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$$d_{\lambda}^n(X, Y) = \sum_{i=1}^m \left[\frac{1}{6|U_i|} \sum_{j=1}^{|U_i|} \sum_{k=1}^n w_{(i,j)} |infT_I(a_k)(u_{(i,j)}) - infT_J(a_k)(u_{(i,j)})|^{\lambda} + |supT_I(a_k)(u_{(i,j)}) - supT_J(a_k)(u_{(i,j)})|^{\lambda} + |infI_I(a_k)(u_{(i,j)}) - infI_J(a_k)(u_{(i,j)})|^{\lambda} + |supI_I(a_k)(u_{(i,j)}) - supI_J(a_k)(u_{(i,j)})|^{\lambda} + |infF_I(a_k)(u_{(i,j)}) - infF_J(a_k)(u_{(i,j)})|^{\lambda} + |supF_I(a_k)(u_{(i,j)}) - supF_J(a_k)(u_{(i,j)})|^{\lambda} \right]^{\frac{1}{\lambda}} \tag{2}$$

Note 3.1. If the weight vector of $(u_{(i,j)})$ is $w_{(i,j)} = \left\{ \left(\frac{1}{n}, \frac{1}{n}, \frac{1}{n}, \dots, \frac{1}{n} \right) \right\}$ and $\lambda = 1$ then equation (1) & (2) is reduced to Hamming distance and Normalized Hamming distance. And if $\lambda = 2$ then equation (1) & (2) is reduced to Euclidean distance and Normalized Euclidean distance.

Definition 3.4. Similarity measures corresponding to the distance measures in Definition 3.1 are defined as follows:

1. $S_H(X, Y) = \frac{1}{1+d_H(X, Y)}$ and $S_E(X, Y) = \frac{1}{1+d_E(X, Y)}$
2. $S_{nH}(X, Y) = \frac{1}{1+d_{nH}(X, Y)}$ and $S_{nE}(X, Y) = \frac{1}{1+d_{nE}(X, Y)}$

Proposition 3.5. Let $S_M(X, Y)$ be similarity measure between two IVNSMSX=(I,A) and Y=(J,A). Then

1. $0 \leq S_M(X, Y) \leq 1$.
2. $S_M(X, Y) = S_M(Y, X)$.
3. $S_M(X, Y) = 1$ if and only if $X = Y$.

Proof: The proof is clear from Definition 3.4.

Example 3.6. Assume that (I,A) and (J,A) are two IVNSMS defined as follow

$(I, A) = \{ (a_1, (\{ \{ [0.4, 0.6], [0.5, 0.6], [0.3, 0.4] \} / u_{(1,1)}, \{ \{ [0.7, 0.8], [0.3, 0.5], [0.2, 0.3] \} / u_{(1,2)}, \{ \{ [0.8, 0.9], [0.2, 0.3], [0.2, 0.3] \} / u_{(1,3)} \})), (\{ \{ [0.5, 0.7], [0.5, 0.6], [0.3, 0.4] \} / u_{(2,1)}, \{ \{ [0.4, 0.7], [0.5, 0.5], [0.6, 0.7] \} / u_{(2,2)} \})), (\{ \{ [0.8, 0.9], [0.2, 0.3], [0.4, 0.6] \} / u_{(3,1)}, \{ \{ [0.6, 0.7], [0.5, 0.8], [0.2, 0.4] \} / u_{(3,2)} \})), (a_2, (\{ \{ [0.5, 0.7], [0.3, 0.5], [0.6, 0.7] \} / u_{(1,1)}, \{ \{ [0.5, 0.8], [0.6, 0.7], [0.2, 0.3] \} / u_{(1,2)}, \{ \{ [0.6, 0.8], [0.2, 0.3], [0.4, 0.5] \} / u_{(1,3)} \})), (\{ \{ [0.8, 0.9], [0.2, 0.3], [0.1, 0.2] \} / u_{(2,1)}, \{ \{ [0.2, 0.4], [0.1, 0.2], [0.7, 0.9] \} / u_{(2,2)} \})), (\{ \{ [0.1, 0.3], [0.1, 0.3], [0.7, 0.9] \} / u_{(3,1)}, \{ \{ [0.7, 0.8], [0.2, 0.3], [0.4, 0.5] \} / u_{(3,2)} \})))$

$(J, A) = \{ (a_1, (\{ \{ [0.5, 0.6], [0.2, 0.4], [0.4, 0.5] \} / u_{(1,1)}, \{ \{ [0.4, 0.5], [0.1, 0.3], [0.4, 0.6] \} / u_{(1,2)}, \{ \{ [0.6, 0.8], [0.4, 0.5], [0.2, 0.4] \} / u_{(1,3)} \})), (\{ \{ [0.5, 0.7], [0.6, 0.7], [0.4, 0.6] \} / u_{(2,1)}, \{ \{ [0.7, 0.8], [0.2, 0.3], [0.4, 0.5] \} / u_{(2,2)} \})), (\{ \{ [0.1, 0.2], [0.5, 0.6], [0.8, 0.9] \} / u_{(3,1)}, \{ \{ [0.5, 0.8], [0.2, 0.5], [0.1, 0.2] \} / u_{(3,2)} \})), (a_2, (\{ \{ [0.6, 0.7], [0.5, 0.7], [0.2, 0.3] \} / u_{(1,1)}, \{ \{ [0.7, 0.8], [0.1, 0.3], [0.4, 0.5] \} / u_{(1,2)}, \{ \{ [0.3, 0.4], [0.5, 0.6], [0.4, 0.5] \} / u_{(1,3)} \})), (\{ \{ [0.5, 0.6], [0.4, 0.5], [0.2, 0.3] \} / u_{(2,1)}, \{ \{ [0.7, 0.8], [0.1, 0.4], [0.5, 0.8] \} / u_{(2,2)} \})), (\{ \{ [0.5, 0.6], [0.4, 0.6], [0.2, 0.4] \} / u_{(3,1)}, \{ \{ [0.8, 1], [0.2, 0.3], [0.1, 0.2] \} / u_{(3,2)} \})))$

Then their distances are:

1. Hamming Distance: $d_H(X, Y) = 2.933$
2. Normalized hamming distance: $d_{nH}(X, Y) = 0.639$
3. Euclidean distance: $d_E(X, Y) = 0.836$
4. Normalized euclidean distance: $d_{nE}(X, Y) = 0.267$.

Their corresponding similarity measures are:

1. $S_H(X, Y) = 0.254$
2. $S_{nH}(X, Y) = 0.610$
3. $S_E(X, Y) = 0.545$
4. $S_{nE}(X, Y) = 0.789$.

TOPSIS FOR MCDM WITH IVNSMS INFORMATION





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Let $U_{i \in I} U_i$ be the collection of universes which contains collection of possible alternatives, let $A = \{a_1, a_2, \dots, a_k\}$ be the set of parameters under consideration and $D = (D_1, D_2, \dots, D_r)$ be the set of r decision makers who establish the weight vector of the attributes $w = (w_1, w_2, \dots, w_n)^T$ with $\sum_{k=1}^n w_k = 1$ and $0 \leq w_k \leq 1$. The set (I, A) represents the performance of alternatives according to the parameters. Therefore, we proposed the following methodology by using Hamming distance to solve IVNSMS problems based on TOPSIS method.

Step 1: Framing the Decision matrix with IVNSM-sets.

Alternatives rating according to the choice parameter is represented by **IVNSMS** (I, A) and they can be represented in matrix form as follows:

$$D = [d_{(ij)k}]_{m \times n} = \begin{bmatrix} (d_{(1,1)1}) & (d_{(1,1)2}) & \dots & (d_{(1,1)k}) \\ \vdots & \vdots & \dots & \vdots \\ (d_{(1,m_1)1}) & (d_{(1,m_1)2}) & \dots & (d_{(1,m_1)k}) \\ (d_{(2,1)1}) & (d_{(2,1)2}) & \dots & (d_{(2,1)k}) \\ \vdots & \vdots & \dots & \vdots \\ (d_{(2,m_2)1}) & (d_{(2,m_2)2}) & \dots & (d_{(2,m_2)k}) \\ \vdots & \vdots & \dots & \vdots \\ (d_{(i,1)1}) & (d_{(i,1)2}) & \dots & (d_{(i,1)k}) \\ \vdots & \vdots & \dots & \vdots \\ (d_{(i,m_i)1}) & (d_{(i,m_i)2}) & \dots & (d_{(i,m_i)k}) \end{bmatrix}_{m \times n}$$

Here,

$$d_{(ij)k} = \langle [\inf T_I(u_{(ij)}), \sup T_I(u_{(ij)})], [\inf I_I(u_{(ij)}), \sup I_I(u_{(ij)})], [\inf F_I(u_{(ij)}), \sup F_I(u_{(ij)})] \rangle, \quad k = 1, 2, \dots, n, (i, j) = \sum_{i \in I} |U_i| = m \text{ and } |U_i| = m_i.$$

Step 2: Determine the weights of the parameters.

In this process, we have to determine the weights of attributes which is unknown and not same. Decision makers select the Linguistic weighting variable for each attribute which is expressed as an Interval valued neutrosophic set. Then we have to find the threshold interval-valued neutrosophic set for each attribute and use the score function to find the score value. Now, calculate the weightage by the following equation:

$$w_k = \frac{S_F(a_k)}{\sum_k S_F(a_k)} \quad \text{and} \quad \sum_{k=1}^n w_k = 1 \# (3)$$

Step 3: Formation of Weighted decision matrix.

Let us construct weighted decision matrix by

$$X = w_k \cdot D = [w_k \cdot d_{(ij)k}]_{m \times n} = [x_{(ij)k}]_{m \times n},$$

where

$$w_k \cdot d_{(ij)k} = w_k \cdot \langle [\inf T_I(u_{(ij)}), \sup T_I(u_{(ij)})], [\inf I_I(u_{(ij)}), \sup I_I(u_{(ij)})], [\inf F_I(u_{(ij)}), \sup F_I(u_{(ij)})] \rangle$$

and $m = \sum_{i \in I} |U_i|, n = 1, 2, \dots, k$.

Step 4: Positive ideal Solution and Negative ideal solution.

In general, parameters are classified as positive ideal solution and negative ideal solution according to benefit type (α_1) and cost type (α_2) . Let d_k^{w+} and d_k^{w-} be interval valued neutrosophic soft multi positive ideal solution (IVNSMPIS) and Interval valued neutrosophic soft multi negative ideal solution (IVNSMNIS). It can be defined as:

(i). $d_k^{w+} = (d_{U_1,k}^{w+}, d_{U_2,k}^{w+}, \dots, d_{U_i,k}^{w+})$ where





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$$d_{U_{i,k}}^{w^+} = \langle [\max_{i,j}\{\inf T_{I_k} x_{(i,j)}\}, \max_{i,j}\{\sup T_{I_k} x_{(i,j)}\}], [\min_{i,j}\{\inf I_{I_k} x_{(i,j)}\}, \min_{i,j}\{\sup I_{I_k} x_{(i,j)}\}], [\min_{i,j}\{\inf F_{I_k} x_{(i,j)}\}, \min_{i,j}\{\sup F_{I_k} x_{(i,j)}\}] \rangle. \text{ Here } k \in \alpha_1 \text{ and } k = 1, 2, \dots, n.$$

$$d_{U_{i,k}}^{w^+} = \langle [\min_{i,j}\{\inf T_{I_k} x_{(i,j)}\}, \min_{i,j}\{\sup T_{I_k} x_{(i,j)}\}], [\max_{i,j}\{\inf I_{I_k} x_{(i,j)}\}, \max_{i,j}\{\sup I_{I_k} x_{(i,j)}\}], [\max_{i,j}\{\inf F_{I_k} x_{(i,j)}\}, \max_{i,j}\{\sup F_{I_k} x_{(i,j)}\}] \rangle. \text{ Here } k \in \alpha_2 \text{ and } k = 1, 2, \dots, n.$$

(ii). $d_k^{w^-} = (d_{U_{1,k}}^{w^-}, d_{U_{2,k}}^{w^-}, \dots, d_{U_{i,k}}^{w^-})$ where

$$d_{U_{i,k}}^{w^-} = \langle [\min_{i,j}\{\inf T_{I_k} x_{(i,j)}\}, \min_{i,j}\{\sup T_{I_k} x_{(i,j)}\}], [\max_{i,j}\{\inf I_{I_k} x_{(i,j)}\}, \max_{i,j}\{\sup I_{I_k} x_{(i,j)}\}], [\max_{i,j}\{\inf F_{I_k} x_{(i,j)}\}, \max_{i,j}\{\sup F_{I_k} x_{(i,j)}\}] \rangle. \text{ Here } k \in \alpha_1 \text{ and } k = 1, 2, \dots, n.$$

$$d_{U_{i,k}}^{w^-} = \langle [\max_{i,j}\{\inf T_{I_k} x_{(i,j)}\}, \max_{i,j}\{\sup T_{I_k} x_{(i,j)}\}], [\min_{i,j}\{\inf I_{I_k} x_{(i,j)}\}, \min_{i,j}\{\sup I_{I_k} x_{(i,j)}\}], [\min_{i,j}\{\inf F_{I_k} x_{(i,j)}\}, \min_{i,j}\{\sup F_{I_k} x_{(i,j)}\}] \rangle. \text{ Here } k \in \alpha_2 \text{ and } k = 1, 2, \dots, n.$$

Step 5: Calculate the distance between X and IVNSMPIS, X and IVNSMNIS.

Now, we have to find the hamming distance between alternatives $(x_{(i,j)})$ in X and IVNSMPIS with $d_H(X, d_k^{w^+})$.

$$d_H((x_{(i,j)}), d_k^{w^+}) = \sum_{i=1}^m \left[\sum_{j=1}^{|U_i|} \sum_{k=1}^n \frac{1}{6} \left| \inf T_X(a_k)(x_{(i,j)}) - \inf T_{d_k^{w^+}}(a_k)(x_{(i,j)}) \right| + \left| \sup T_X(a_k)(u_{(i,j)}) - \sup T_{d_k^{w^+}}(a_k)(u_{(i,j)}) \right| + \left| \inf I_X(a_k)(u_{(i,j)}) - \inf I_{d_k^{w^+}}(a_k)(u_{(i,j)}) \right| + \left| \sup I_X(a_k)(u_{(i,j)}) - \sup I_{d_k^{w^+}}(a_k)(u_{(i,j)}) \right| + \left| \inf F_X(a_k)(u_{(i,j)}) - \inf F_{d_k^{w^+}}(a_k)(u_{(i,j)}) \right| + \left| \sup F_X(a_k)(u_{(i,j)}) - \sup F_{d_k^{w^+}}(a_k)(u_{(i,j)}) \right| \right], \tag{4}$$

Similarly,

$$d_H((x_{(i,j)}), d_k^{w^-}) = \sum_{i=1}^m \left[\sum_{j=1}^{|U_i|} \sum_{k=1}^n \frac{1}{6} \left| \inf T_X(a_k)(x_{(i,j)}) - \inf T_{d_k^{w^-}}(a_k)(x_{(i,j)}) \right| + \left| \sup T_X(a_k)(u_{(i,j)}) - \sup T_{d_k^{w^-}}(a_k)(u_{(i,j)}) \right| + \left| \inf I_X(a_k)(u_{(i,j)}) - \inf I_{d_k^{w^-}}(a_k)(u_{(i,j)}) \right| + \left| \sup I_X(a_k)(u_{(i,j)}) - \sup I_{d_k^{w^-}}(a_k)(u_{(i,j)}) \right| + \left| \inf F_X(a_k)(u_{(i,j)}) - \inf F_{d_k^{w^-}}(a_k)(u_{(i,j)}) \right| + \left| \sup F_X(a_k)(u_{(i,j)}) - \sup F_{d_k^{w^-}}(a_k)(u_{(i,j)}) \right| \right], \tag{5}$$

Step 6: Calculate the Relative closeness coefficient:

The relative closeness coefficient of combination of each alternative $(x_{(i,j)})$ in X is calculated with

$$RCC_{(x_{(i,j)})} = \frac{d_H((x_{(i,j)}), d_k^{w^+})}{d_H((x_{(i,j)}), d_k^{w^+}) + d_H((x_{(i,j)}), d_k^{w^-})} \tag{6}$$

Step 7: Rank of Alternatives

Use the $RCC_{(x_{(i,j)})}$ to rank the alternatives in ascending order and find the best alternatives from the given universes.

A NUMERICAL APPLICATION

In this section, we solve a real-life situation to show the efficaciousness of the proposed TOPSIS approach.





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Example 5.1. Suppose that a student X wants to choose an educational institution, an affordable accommodation to stay peacefully and a part-time job to pursue his higher education with his own revenue. Let (I, A) be an **IVNSMS** which describes "educational institutions", "accommodations" and "part-time jobs" respectively that Student X is considering to choose a good educational institution, an affordable accommodation to stay, and a part-time job that does not affect his studies. Let $U_1 = \{u_{(1,1)} = \text{University}, u_{(1,2)} = \text{Government institution}, u_{(1,3)} = \text{Aided institution}, u_{(1,4)} = \text{Private self finance institution}\}$ be the universe for educational institutions, $U_2 = \{u_{(2,1)} = \text{College hostel}, u_{(2,2)} = \text{Private hostel}, u_{(2,3)} = \text{PG}\}$ be the universe for accommodation and $U_3 = \{u_{(3,1)} = \text{Tutor}, u_{(3,2)} = \text{Library assistant}, u_{(3,3)} = \text{Shop assistant}, u_{(3,4)} = \text{Bank teller / Cashier}\}$ be the universe for part-time jobs. Let $\{E_{U_1}, E_{U_2}, E_{U_3}\}$ be a collection of parameters which describes above universes, where

$E_{U_1} = \{e_{U_1,1} = \text{nice campus atmosphere}, e_{U_1,2} = \text{affordable fee structure}, e_{U_1,3} = \text{best career opportunity}, e_{U_1,4} = \text{good research environment}\}$

$E_{U_2} = \{e_{U_2,1} = \text{reasonable fee}, e_{U_2,2} = \text{hygienic atmosphere}, e_{U_2,3} = \text{taste \& nutritious food}\}$

$E_{U_3} = \{e_{U_3,1} = \text{60 hour working}, e_{U_3,2} = \text{good salary}\}$.

Let $U = \prod_{i=1}^3 IVN(U_i)$, $E = \prod_{i=1}^3 E_{U_i}$ and $A \subseteq E$ such that

$A = \{a_1 = (e_{U_1,1}, e_{U_2,2}, e_{U_3,1}), a_2 = (e_{U_1,2}, e_{U_2,1}, e_{U_3,2}), a_3 = (e_{U_1,4}, e_{U_2,3}, e_{U_3,1}), a_4 = (e_{U_1,3}, e_{U_2,2}, e_{U_3,2}), a_5 = (e_{U_1,4}, e_{U_2,1}, e_{U_3,1}), a_6 = (e_{U_1,3}, e_{U_2,3}, e_{U_3,2})\}$.

Let E_1, E_2 be two well wishers (experts) of Student X , who gives some advice to Student X to lead his career. Now Student X wants to make a choice of combination for his future, from the set of choice parameters. The final assessment of Student X in the form of interval valued neutrosophic numbers is represented by the **IVNSMS** (I, A) in Table 1.

Step 1: Framing the Decision matrix.

We present the IVNSMS (I, A) in the tabular form:

Step 2: Determine the weights of the parameters.

To evaluate the importance of the attributes, the well wishers E_1 and E_2 gave interval valued neutrosophic numbers to the attributes as shown in the table.

Now, we have to find a threshold interval-valued neutrosophic set $(\alpha, \beta, \gamma)_{(A)}^{avg}$ to the attributes in A by using avg-level decision rule;

$$\langle \alpha, \beta, \gamma \rangle_{(A)}^{avg}(a_1) = \langle [0.45, 0.55], [0.25, 0.35], [0.5, 0.6] \rangle$$

$$\langle \alpha, \beta, \gamma \rangle_{(A)}^{avg}(a_2) = \langle [0.8, 0.95], [0.2, 0.3], [0.1, 0.2] \rangle$$

$$\langle \alpha, \beta, \gamma \rangle_{(A)}^{avg}(a_3) = \langle [0.65, 0.8], [0.25, 0.4], [0.25, 0.35] \rangle$$

$$\langle \alpha, \beta, \gamma \rangle_{(A)}^{avg}(a_4) = \langle [0.45, 0.55], [0.5, 0.6], [0.5, 0.6] \rangle$$

$$\langle \alpha, \beta, \gamma \rangle_{(A)}^{avg}(a_5) = \langle [0.25, 0.35], [0.65, 0.8], [0.4, 0.45] \rangle$$

$$\langle \alpha, \beta, \gamma \rangle_{(A)}^{avg}(a_6) = \langle [0.75, 0.9], [0.2, 0.35], [0.25, 0.4] \rangle$$

Now, we shall use the score function in Definition 2.5 to get the score of each alternatives.

$$S_F(a_1) = 1.65, S_F(a_2) = 2.4750, S_F(a_3) = 2.1000, S_F(a_4) = 1.4000, S_F(a_5) = 1.1500, S_F(a_6) = 2.2250$$

Calculate weight of alternatives by using equation (3).

$$w_1 = 0.1500, w_2 = 0.2250, w_3 = 0.1909, w_4 = 0.1273, w_5 = 0.1045, w_6 = 0.2023, \text{ where } \sum_{k=1}^6 w_k = 1.$$

Step 3: Formation of weighted decision matrix.

Step 4: Positive ideal Solution and Negative ideal solution.

The IVNSMPIS (d_k^+) and IVNSMNIS (d_k^-) can be attained from the weighted decision matrix (see Table 3.) given in Table 4 and Table 5:



**Step 5: Calculate the distance between X and IVNSMPIS, X and IVNSMNIS.**

The hamming distance measure of each alternative $(x_{(i,j)})$ in X from IVNSMPIS are calculated by employing Eq.(4) as shown in Table 6:

The hamming distance measures of each alternative $(x_{(i,j)})$ in X from the IVNSMNIS are calculated by using Eq.(5) as given in Table: 7.

Step 6: Calculate the Relative closeness coefficient:

We compute the relative closeness co-efficient $RCC_{((i,j))}$ by employing Eq. (6) as shown in Table: 8.

Step 7: Rank of Alternatives

When we rank the combination of alternatives by relative closeness co-efficient, we get

$$(u_{(1,1)}, u_{(2,2)}, u_{(3,4)}) < (u_{(1,1)}, u_{(2,2)}, u_{(3,2)}) < (u_{(1,1)}, u_{(2,3)}, u_{(3,4)}) < (u_{(1,1)}, u_{(2,3)}, u_{(3,2)}) < (u_{(1,1)}, u_{(2,2)}, u_{(3,1)}).$$

Consequently, Student X will choose University for his higher studies, stay in a private hostel and work as a Bank teller/Cashier for his financial support.

CONCLUSION

Interval valued neutrosophic soft multiset is a more effective tool for describing objects in inconsistent and indeterminate situations, which is a generalization of interval valued neutrosophic soft sets. In this paper, we define distance and similarity measures between IVNSMS with their properties and examples. Further, by employing the proposed Hamming distance we extend the TOPSIS method to IVNSMS. Finally, we resolved a real life problem with the help of the proposed TOPSIS algorithm, and an optimal decision was obtained.

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Table 1: Tabular representation of Decision matrix

U_i	a_1	a_2	a_3
$u_{(1,1)}$	[0.7,0.9],[0.2,0.3],[0.1,0.2]	[0.8,0.9],[0.2,0.3],[0.1,0.2]	[0.8,0.9],[0.3,0.3],[0.1,0.3]
$u_{(1,2)}$	[0.8,0.9],[0.3,0.3],[0.5,0.6]	[0.7,0.8],[0.3,0.3],[0.5,0.6]	[0.4,0.6],[0.3,0.3],[0.5,0.6]
$u_{(1,3)}$	[0.5,0.7],[0.4,0.5],[0.2,0.4]	[0.6,0.7],[0.4,0.5],[0.2,0.4]	[0.6,0.7],[0.4,0.5],[0.2,0.4]
$u_{(1,4)}$	[0.7,0.8],[0.4,0.5],[0.3,0.5]	[0.5,0.6],[0.2,0.5],[0.3,0.5]	[0.7,0.8],[0.4,0.5],[0.3,0.6]
$u_{(2,1)}$	[0.5,0.6],[0.2,0.4],[0.1,0.3]	[0.4,0.6],[0.5,0.6],[0.1,0.3]	[0.4,0.6],[0.5,0.6],[0.1,0.3]
$u_{(2,2)}$	[0.6,0.7],[0.5,0.6],[0.4,0.5]	[0.7,0.9],[0.2,0.4],[0.1,0.2]	[0.8,0.9],[0.2,0.4],[0.3,0.5]
$u_{(2,3)}$	[0.8,0.9],[0.2,0.4],[0.3,0.5]	[0.4,0.6],[0.4,0.5],[0.4,0.5]	[0.5,0.7],[0.5,0.5],[0.3,0.5]
$u_{(3,1)}$	[0.8,0.9],[0.2,0.4],[0.1,0.3]	[0.7,0.9],[0.2,0.4],[0.1,0.3]	[0.8,0.9],[0.2,0.4],[0.1,0.3]
$u_{(3,2)}$	[0.7,0.8],[0.5,0.6],[0.4,0.5]	[0.4,0.5],[0.5,0.6],[0.4,0.5]	[0.7,0.8],[0.5,0.6],[0.4,0.5]





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$u_{(3,3)}$	[0.7,0.8],[0.3,0.5],[0.2,0.3]	[0.8,0.9],[0.2,0.3],[0.1,0.2]	[0.7,0.8],[0.3,0.5],[0.2,0.3]
$u_{(3,4)}$	[0.6,0.8],[0.5,0.6],[0.4,0.5]	[0.6,0.7],[0.3,0.5],[0.4,0.6]	[0.6,0.8],[0.5,0.6],[0.4,0.5]
U_i	a_4	a_5	a_6
$u_{(1,1)}$	[0.5,0.8],[0.2,0.4],[0.3,0.5]	[0.8,0.9],[0.3,0.3],[0.1,0.3]	[0.5,0.8],[0.2,0.4],[0.3,0.5]
$u_{(1,2)}$	[0.8,0.9],[0.3,0.3],[0.5,0.6]	[0.4,0.6],[0.3,0.3],[0.5,0.6]	[0.8,0.9],[0.3,0.3],[0.5,0.6]
$u_{(1,3)}$	[0.6,0.7],[0.4,0.5],[0.2,0.4]	[0.6,0.7],[0.4,0.5],[0.2,0.4]	[0.6,0.7],[0.4,0.5],[0.2,0.4]
$u_{(1,4)}$	[0.4,0.7],[0.4,0.5],[0.2,0.5]	[0.7,0.8],[0.4,0.5],[0.3,0.6]	[0.4,0.7],[0.4,0.5],[0.2,0.5]
$u_{(2,1)}$	[0.5,0.6],[0.2,0.4],[0.1,0.3]	[0.3,0.4],[0.6,0.7],[0.1,0.3]	[0.4,0.6],[0.5,0.6],[0.1,0.3]
$u_{(2,2)}$	[0.6,0.7],[0.5,0.6],[0.4,0.5]	[0.7,0.9],[0.2,0.4],[0.1,0.2]	[0.8,0.9],[0.2,0.4],[0.3,0.5]
$u_{(2,3)}$	[0.8,0.9],[0.2,0.4],[0.3,0.5]	[0.4,0.6],[0.4,0.5],[0.4,0.5]	[0.6,0.7],[0.4,0.4],[0.3,0.5]
$u_{(3,1)}$	[0.7,0.9],[0.2,0.4],[0.1,0.3]	[0.8,0.9],[0.2,0.4],[0.1,0.3]	[0.7,0.9],[0.2,0.4],[0.1,0.3]
$u_{(3,2)}$	[0.4,0.5],[0.5,0.6],[0.4,0.5]	[0.7,0.8],[0.5,0.6],[0.4,0.5]	[0.4,0.5],[0.5,0.6],[0.4,0.5]
$u_{(3,3)}$	[0.8,0.9],[0.2,0.3],[0.1,0.2]	[0.7,0.8],[0.3,0.5],[0.2,0.3]	[0.8,0.9],[0.2,0.3],[0.1,0.2]
$u_{(3,4)}$	[0.6,0.7],[0.3,0.5],[0.4,0.6]	[0.6,0.8],[0.5,0.6],[0.4,0.5]	[0.6,0.7],[0.3,0.5],[0.4,0.6]

Table 1: Tabular representation of linguistic variable

Parameters	E_1	E_2
a_1	[0.5,0.6],[0.3,0.4],[0.4,0.5]	[0.4,0.5],[0.2,0.3],[0.6,0.7]
a_2	[0.9,1.0],[0.1,0.2],[0.0,1]	[0.7,0.9],[0.3,0.4],[0.2,0.3]
a_3	[0.6,0.8],[0.3,0.4],[0.3,0.4]	[0.7,0.8],[0.2,0.4],[0.2,0.3]
a_4	[0.5,0.6],[0.4,0.5],[0.5,0.6]	[0.4,0.5],[0.6,0.7],[0.5,0.6]
a_5	[0.3,0.4],[0.5,0.7],[0.3,0.4]	[0.2,0.3],[0.8,0.9],[0.5,0.5]
a_6	[0.7,0.8],[0.1,0.2],[0.1,0.3]	[0.8,1.0],[0.3,0.5],[0.4,0.5]

Table 3. represents the tabular form of the weighted decision matrix.

U_i	a_1	a_2	a_3
$u_{(1,1)}$	[0.105,0.135],[0.03,0.045],[0.015,0.03]	[0.18,0.2025],[0.045,0.0675],[0.0225,0.045]	[0.1527,0.1718],[0.0573,0.0573],[0.0191,0.0573]
$u_{(1,2)}$	[0.12,0.135],[0.045,0.045],[0.075,0.09]	[0.1575,0.18],[0.0675,0.0675],[0.1125,0.135]	[0.0764,0.1145],[0.0573,0.0573],[0.0955,0.1145]
$u_{(1,3)}$	[0.075,0.105],[0.06,0.075],[0.03,0.06]	[0.135,0.1575],[0.09,0.1125],[0.045,0.09]	[0.1145,0.1336],[0.0764,0.0955],[0.0382,0.0764]
$u_{(1,4)}$	[0.105,0.12],[0.06,0.075],[0.045,0.075]	[0.1125,0.135],[0.045,0.1125],[0.0675,0.1125]	[0.1336,0.1527],[0.0764,0.0955],[0.0573,0.1145]
$u_{(2,1)}$	[0.075,0.09],[0.03,0.06],[0.015,0.045]	[0.0675,0.09],[0.135,0.1575],[0.0225,0.0675]	[0.0764,0.1145],[0.0955,0.1145],[0.0191,0.0573]
$u_{(2,2)}$	[0.09,0.105],[0.075,0.09],[0.06,0.075]	[0.1575,0.2025],[0.045,0.09],[0.0225,0.045]	[0.1527,0.1718],[0.0382,0.0764],[0.0573,0.0955]
$u_{(2,3)}$	[0.12,0.135],[0.03,0.06],[0.045,0.075]	[0.09,0.135],[0.09,0.1125],[0.09,0.1125]	[0.1145,0.1336],[0.0764,0.0764],[0.0573,0.0955]
$u_{(3,1)}$	[0.12,0.135],[0.03,0.06],[0.015,0.045]	[0.1575,0.2025],[0.045,0.09],[0.0225,0.0675]	[0.1527,0.1718],[0.0382,0.0764],[0.0191,0.0573]
$u_{(3,2)}$	[0.105,0.12],[0.075,0.09],[0.06,0.075]	[0.09,0.1125],[0.1125,0.135],[0.09,0.1125]	[0.1336,0.1527],[0.0955,0.1145],[0.0764,0.0955]
$u_{(3,3)}$	[0.105,0.12],[0.045,0.075],[0.03,0.045]	[0.18,0.2025],[0.045,0.0675],[0.0225,0.045]	[0.1336,0.1527],[0.0573,0.0955],[0.0382,0.0573]
$u_{(3,4)}$	[0.09,0.12],[0.075,0.09],[0.06,0.075]	[0.135,0.1575],[0.0675,0.1125],[0.09,0.135]	[0.1145,0.1527],[0.0955,0.1145],[0.0764,0.0955]





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U_i	a_4	a_5	a_6
$u_{(1,1)}$	[0.0636,0.1018],[0.0255,0.0509],[0.0382,0.0636]	[0.0836,0.0941],[0.0314,0.0314],[0.0105,0.0314]	[0.1011,0.1618],[0.0405,0.0809],[0.0607,0.1011]
$u_{(1,2)}$	[0.1018,0.1145],[0.0382,0.0382],[0.0636,0.0764]	[0.0418,0.0627],[0.0314,0.0314],[0.0523,0.0627]	[0.1618,0.1820],[0.0607,0.0607],[0.1011,0.1214]
$u_{(1,3)}$	[0.0764,0.0891],[0.0509,0.0636],[0.0255,0.0636]	[0.0627,0.0732],[0.0418,0.0523],[0.0209,0.0627]	[0.1214,0.1416],[0.0809,0.1011],[0.0405,0.0809]
$u_{(1,4)}$	[0.0509,0.0891],[0.0509,0.0636],[0.0255,0.0636]	[0.0732,0.0836],[0.0418,0.0523],[0.0314,0.0627]	[0.0809,0.1416],[0.0809,0.1011],[0.0405,0.1011]
$u_{(2,1)}$	[0.0636,0.0764],[0.0255,0.0509],[0.0127,0.0382]	[0.0314,0.0418],[0.0627,0.0732],[0.0105,0.0314]	[0.0809,0.1214],[0.1011,0.1214],[0.0202,0.0607]
$u_{(2,2)}$	[0.0764,0.0891],[0.0636,0.0764],[0.0509,0.0636]	[0.0732,0.0941],[0.0209,0.0418],[0.0105,0.0209]	[0.1618,0.1820],[0.0405,0.0809],[0.0607,0.1011]
$u_{(2,3)}$	[0.1018,0.1145],[0.0255,0.0509],[0.0382,0.0636]	[0.0418,0.0627],[0.0418,0.0523],[0.0418,0.0523]	[0.1214,0.1416],[0.0809,0.0809],[0.0607,0.1011]
$u_{(3,1)}$	[0.0891,0.1145],[0.0255,0.0509],[0.0127,0.0382]	[0.0836,0.0941],[0.0209,0.0418],[0.0105,0.0314]	[0.1416,0.1820],[0.0405,0.0809],[0.0202,0.0607]
$u_{(3,2)}$	[0.0509,0.0636],[0.0636,0.0764],[0.0509,0.0636]	[0.0732,0.0836],[0.0523,0.0627],[0.0418,0.0523]	[0.0809,0.1011],[0.1011,0.1214],[0.0809,0.1011]
$u_{(3,3)}$	[0.1018,0.1145],[0.0255,0.0382],[0.0127,0.0255]	[0.0732,0.0836],[0.0314,0.0523],[0.0209,0.0314]	[0.1618,0.1820],[0.0405,0.0607],[0.0202,0.0405]
$u_{(3,4)}$	[0.0764,0.0891],[0.0382,0.0636],[0.0509,0.0764]	[0.0627,0.0836],[0.0523,0.0627],[0.0418,0.0523]	[0.1214,0.1416],[0.0607,0.1011],[0.0809,0.1214]

Table 2: Tabular representation of (d_k^{w+})

U_i	a_1	a_2	a_3
U_1	[0.12,0.135],[0.03,0.045],[0.015,0.03]	[0.18,0.2025],[0.045,0.0675],[0.0225,0.0450]	[0.1527,0.1718],[0.0573,0.0573],[0.0191,0.0573]
U_2	[0.12,0.135],[0.03,0.06],[0.015,0.045]	[0.1575,0.2025],[0.045,0.09],[0.0225,0.045]	[0.1527,0.1718],[0.0382,0.0764],[0.0191,0.0573]
U_3	[0.12,0.135],[0.075,0.09],[0.06,0.075]	[0.18,0.2025],[0.1125,0.135],[0.09,0.135]	[0.1527,0.1718],[0.0955,0.1145],[0.0764,0.0955]
U_i	a_4	a_5	a_6
U_1	[0.1018,0.1145],[0.0255,0.0382],[0.0255,0.0509]	[0.0836,0.0941],[0.0314,0.0314],[0.0105,0.0314]	[0.1618,0.1820],[0.0405,0.0607],[0.0405,0.0809]
U_2	[0.1018,0.1145],[0.0255,0.0509],[0.0127,0.0382]	[0.0732,0.0941],[0.0209,0.0418],[0.0105,0.0209]	[0.1618,0.1820],[0.0405,0.0809],[0.0202,0.0607]
U_3	[0.1018,0.1145],[0.0636,0.0764],[0.0509,0.0764]	[0.0836,0.0941],[0.0523,0.0627],[0.0418,0.0523]	[0.1618,0.1820],[0.1011,0.1214],[0.0809,0.1214]

Table 3: Tabular representation of (d_k^{w-})

U_i	a_1	a_2	a_3
U_1	[0.0750,0.1050],[0.0600,0.0750],[0.0750,0.0900]	[0.1125,0.1350],[0.0900,0.1125],[0.1125,0.1350]	[0.0764,0.1145],[0.0764,0.0955],[0.0955,0.1145]
U_2	[0.0750,0.0900],[0.0750,0.0900],[0.0600,0.0750]	[0.0675,0.0900],[0.1350,0.1575],[0.0900,0.1125]	[0.0764,0.1145],[0.0955,0.1145],[0.0573,0.0955]
U_3	[0.0900,0.1200],[0.0300,0.0600],[0.0150,0.0450]	[0.0900,0.1125],[0.0450,0.0675],[0.0225,0.0450]	[0.1145,0.1527],[0.0382,0.0764],[0.0191,0.0573]
U_i	a_4	a_5	a_6





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U_1	[0.0509,0.0891],[0.0509,0.0636],[0.0636,0.0764]	[0.0418,0.0627],[0.0418,0.0523],[0.0523,0.0627]	[0.0809,0.1416],[0.0809,0.1011],[0.1011,0.1214]
U_2	[0.0636,0.0764],[0.0636,0.0764],[0.0509,0.0636]	[0.0314,0.0418],[0.0627,0.0732],[0.0418,0.0523]	[0.0809,0.1214],[0.1011,0.1214],[0.0607,0.1011]
U_3	[0.0509,0.0636],[0.0255,0.0382],[0.0127,0.0255]	[0.0627,0.0836],[0.0209,0.0418],[0.0105,0.0314]	[0.0809,0.1011],[0.0405,0.0607],[0.0202,0.0405]

Table 4: Hamming distance between alternatives and IVNSMPIS

Alternatives	d_H^+	Alternatives	d_H^+	Alternatives	d_H^+
$(u_{(1,1)}, u_{(2,1)}, u_{(3,1)})$	0.4258	$(u_{(1,2)}, u_{(2,2)}, u_{(3,1)})$	0.4417	$(u_{(1,3)}, u_{(2,3)}, u_{(3,1)})$	0.5111
$(u_{(1,1)}, u_{(2,1)}, u_{(3,2)})$	0.3387	$(u_{(1,2)}, u_{(2,2)}, u_{(3,2)})$	0.3546	$(u_{(1,3)}, u_{(2,3)}, u_{(3,2)})$	0.4239
$(u_{(1,1)}, u_{(2,1)}, u_{(3,3)})$	0.4277	$(u_{(1,2)}, u_{(2,2)}, u_{(3,3)})$	0.4435	$(u_{(1,3)}, u_{(2,3)}, u_{(3,3)})$	0.5129
$(u_{(1,1)}, u_{(2,1)}, u_{(3,4)})$	0.3277	$(u_{(1,2)}, u_{(2,2)}, u_{(3,4)})$	0.3435	$(u_{(1,3)}, u_{(2,3)}, u_{(3,4)})$	0.4129
$(u_{(1,1)}, u_{(2,2)}, u_{(3,1)})$	0.3170	$(u_{(1,2)}, u_{(2,3)}, u_{(3,1)})$	0.5172	$(u_{(1,4)}, u_{(2,1)}, u_{(3,1)})$	0.5708
$(u_{(1,1)}, u_{(2,2)}, u_{(3,2)})$	0.2299	$(u_{(1,2)}, u_{(2,3)}, u_{(3,2)})$	0.4301	$(u_{(1,4)}, u_{(2,1)}, u_{(3,2)})$	0.4837
$(u_{(1,1)}, u_{(2,2)}, u_{(3,3)})$	0.3188	$(u_{(1,2)}, u_{(2,3)}, u_{(3,3)})$	0.5190	$(u_{(1,4)}, u_{(2,1)}, u_{(3,3)})$	0.5726
$(u_{(1,1)}, u_{(2,2)}, u_{(3,4)})$	0.2188	$(u_{(1,2)}, u_{(2,3)}, u_{(3,4)})$	0.4190	$(u_{(1,4)}, u_{(2,1)}, u_{(3,4)})$	0.4726
$(u_{(1,1)}, u_{(2,3)}, u_{(3,1)})$	0.3925	$(u_{(1,3)}, u_{(2,1)}, u_{(3,1)})$	0.5444	$(u_{(1,4)}, u_{(2,2)}, u_{(3,1)})$	0.4620
$(u_{(1,1)}, u_{(2,3)}, u_{(3,2)})$	0.3054	$(u_{(1,3)}, u_{(2,1)}, u_{(3,2)})$	0.4573	$(u_{(1,4)}, u_{(2,2)}, u_{(3,2)})$	0.3748
$(u_{(1,1)}, u_{(2,3)}, u_{(3,3)})$	0.3943	$(u_{(1,3)}, u_{(2,1)}, u_{(3,3)})$	0.5462	$(u_{(1,4)}, u_{(2,2)}, u_{(3,3)})$	0.4638
$(u_{(1,1)}, u_{(2,3)}, u_{(3,4)})$	0.2943	$(u_{(1,3)}, u_{(2,1)}, u_{(3,4)})$	0.4462	$(u_{(1,4)}, u_{(2,2)}, u_{(3,4)})$	0.3638
$(u_{(1,2)}, u_{(2,1)}, u_{(3,1)})$	0.5505	$(u_{(1,3)}, u_{(2,2)}, u_{(3,1)})$	0.4356	$(u_{(1,4)}, u_{(2,3)}, u_{(3,1)})$	0.5375
$(u_{(1,2)}, u_{(2,1)}, u_{(3,2)})$	0.4634	$(u_{(1,3)}, u_{(2,2)}, u_{(3,2)})$	0.3484	$(u_{(1,4)}, u_{(2,3)}, u_{(3,2)})$	0.4503
$(u_{(1,2)}, u_{(2,1)}, u_{(3,3)})$	0.5523	$(u_{(1,3)}, u_{(2,2)}, u_{(3,3)})$	0.4374	$(u_{(1,4)}, u_{(2,3)}, u_{(3,3)})$	0.5393
$(u_{(1,2)}, u_{(2,1)}, u_{(3,4)})$	0.4523	$(u_{(1,3)}, u_{(2,2)}, u_{(3,4)})$	0.3374	$(u_{(1,4)}, u_{(2,3)}, u_{(3,4)})$	0.4393

Table 5: Hamming distance between alternatives and IVNSMNIS

Alternatives	d_H^-	Alternatives	d_H^-	Alternatives	d_H^-
$(u_{(1,1)}, u_{(2,1)}, u_{(3,1)})$	0.4405	$(u_{(1,2)}, u_{(2,2)}, u_{(3,1)})$	0.4246	$(u_{(1,3)}, u_{(2,3)}, u_{(3,1)})$	0.3553
$(u_{(1,1)}, u_{(2,1)}, u_{(3,2)})$	0.5276	$(u_{(1,2)}, u_{(2,2)}, u_{(3,2)})$	0.5117	$(u_{(1,3)}, u_{(2,3)}, u_{(3,2)})$	0.4424
$(u_{(1,1)}, u_{(2,1)}, u_{(3,3)})$	0.4387	$(u_{(1,2)}, u_{(2,2)}, u_{(3,3)})$	0.4228	$(u_{(1,3)}, u_{(2,3)}, u_{(3,3)})$	0.3534
$(u_{(1,1)}, u_{(2,1)}, u_{(3,4)})$	0.5387	$(u_{(1,2)}, u_{(2,2)}, u_{(3,4)})$	0.5228	$(u_{(1,3)}, u_{(2,3)}, u_{(3,4)})$	0.4534
$(u_{(1,1)}, u_{(2,2)}, u_{(3,1)})$	0.5493	$(u_{(1,2)}, u_{(2,3)}, u_{(3,1)})$	0.3491	$(u_{(1,4)}, u_{(2,1)}, u_{(3,1)})$	0.2955
$(u_{(1,1)}, u_{(2,2)}, u_{(3,2)})$	0.6364	$(u_{(1,2)}, u_{(2,3)}, u_{(3,2)})$	0.4363	$(u_{(1,4)}, u_{(2,1)}, u_{(3,2)})$	0.3827
$(u_{(1,1)}, u_{(2,2)}, u_{(3,3)})$	0.5475	$(u_{(1,2)}, u_{(2,3)}, u_{(3,3)})$	0.3473	$(u_{(1,4)}, u_{(2,1)}, u_{(3,3)})$	0.2937
$(u_{(1,1)}, u_{(2,2)}, u_{(3,4)})$	0.6475	$(u_{(1,2)}, u_{(2,3)}, u_{(3,4)})$	0.4473	$(u_{(1,4)}, u_{(2,1)}, u_{(3,4)})$	0.3937
$(u_{(1,1)}, u_{(2,3)}, u_{(3,1)})$	0.4738	$(u_{(1,3)}, u_{(2,1)}, u_{(3,1)})$	0.3219	$(u_{(1,4)}, u_{(2,2)}, u_{(3,1)})$	0.4044
$(u_{(1,1)}, u_{(2,3)}, u_{(3,2)})$	0.5609	$(u_{(1,3)}, u_{(2,1)}, u_{(3,2)})$	0.4091	$(u_{(1,4)}, u_{(2,2)}, u_{(3,2)})$	0.4915
$(u_{(1,1)}, u_{(2,3)}, u_{(3,3)})$	0.4720	$(u_{(1,3)}, u_{(2,1)}, u_{(3,3)})$	0.3201	$(u_{(1,4)}, u_{(2,2)}, u_{(3,3)})$	0.4025
$(u_{(1,1)}, u_{(2,3)}, u_{(3,4)})$	0.5720	$(u_{(1,3)}, u_{(2,1)}, u_{(3,4)})$	0.4201	$(u_{(1,4)}, u_{(2,2)}, u_{(3,4)})$	0.5025
$(u_{(1,2)}, u_{(2,1)}, u_{(3,1)})$	0.3158	$(u_{(1,3)}, u_{(2,2)}, u_{(3,1)})$	0.4308	$(u_{(1,4)}, u_{(2,3)}, u_{(3,1)})$	0.3289
$(u_{(1,2)}, u_{(2,1)}, u_{(3,2)})$	0.4029	$(u_{(1,3)}, u_{(2,2)}, u_{(3,2)})$	0.5179	$(u_{(1,4)}, u_{(2,3)}, u_{(3,2)})$	0.4160
$(u_{(1,2)}, u_{(2,1)}, u_{(3,3)})$	0.3140	$(u_{(1,3)}, u_{(2,2)}, u_{(3,3)})$	0.4289	$(u_{(1,4)}, u_{(2,3)}, u_{(3,3)})$	0.3270
$(u_{(1,2)}, u_{(2,1)}, u_{(3,4)})$	0.4140	$(u_{(1,3)}, u_{(2,2)}, u_{(3,4)})$	0.5289	$(u_{(1,4)}, u_{(2,3)}, u_{(3,4)})$	0.4270





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Table 6: Relative closeness coefficient

RCC	Score	RCC	Score	RCC	Score
$((u_{(1,1)}, u_{(2,1)}, u_{(3,1)}))$	0.4915	$((u_{(1,2)}, u_{(2,2)}, u_{(3,1)}))$	0.5099	$((u_{(1,3)}, u_{(2,3)}, u_{(3,1)}))$	0.5899
$((u_{(1,1)}, u_{(2,1)}, u_{(3,2)}))$	0.3910	$((u_{(1,2)}, u_{(2,2)}, u_{(3,2)}))$	0.4093	$((u_{(1,3)}, u_{(2,3)}, u_{(3,2)}))$	0.4894
$((u_{(1,1)}, u_{(2,1)}, u_{(3,3)}))$	0.4936	$((u_{(1,2)}, u_{(2,2)}, u_{(3,3)}))$	0.5120	$((u_{(1,3)}, u_{(2,3)}, u_{(3,3)}))$	0.5920
$((u_{(1,1)}, u_{(2,1)}, u_{(3,4)}))$	0.3782	$((u_{(1,2)}, u_{(2,2)}, u_{(3,4)}))$	0.3965	$((u_{(1,3)}, u_{(2,3)}, u_{(3,4)}))$	0.4766
$((u_{(1,1)}, u_{(2,2)}, u_{(3,1)}))$	0.3659	$((u_{(1,2)}, u_{(2,3)}, u_{(3,1)}))$	0.5970	$((u_{(1,4)}, u_{(2,1)}, u_{(3,1)}))$	0.6589
$((u_{(1,1)}, u_{(2,2)}, u_{(3,2)}))$	0.2654	$((u_{(1,2)}, u_{(2,3)}, u_{(3,2)}))$	0.4964	$((u_{(1,4)}, u_{(2,1)}, u_{(3,2)}))$	0.5583
$((u_{(1,1)}, u_{(2,2)}, u_{(3,3)}))$	0.3680	$((u_{(1,2)}, u_{(2,3)}, u_{(3,3)}))$	0.5991	$((u_{(1,4)}, u_{(2,1)}, u_{(3,3)}))$	0.6610
$((u_{(1,1)}, u_{(2,2)}, u_{(3,4)}))$	0.2526	$((u_{(1,2)}, u_{(2,3)}, u_{(3,4)}))$	0.4837	$((u_{(1,4)}, u_{(2,1)}, u_{(3,4)}))$	0.5455
$((u_{(1,1)}, u_{(2,3)}, u_{(3,1)}))$	0.4531	$((u_{(1,3)}, u_{(2,1)}, u_{(3,1)}))$	0.6284	$((u_{(1,4)}, u_{(2,2)}, u_{(3,1)}))$	0.5333
$((u_{(1,1)}, u_{(2,3)}, u_{(3,2)}))$	0.3525	$((u_{(1,3)}, u_{(2,1)}, u_{(3,2)}))$	0.5278	$((u_{(1,4)}, u_{(2,2)}, u_{(3,2)}))$	0.4327
$((u_{(1,1)}, u_{(2,3)}, u_{(3,3)}))$	0.4552	$((u_{(1,3)}, u_{(2,1)}, u_{(3,3)}))$	0.6305	$((u_{(1,4)}, u_{(2,2)}, u_{(3,3)}))$	0.5354
$((u_{(1,1)}, u_{(2,3)}, u_{(3,4)}))$	0.3397	$((u_{(1,3)}, u_{(2,1)}, u_{(3,4)}))$	0.5151	$((u_{(1,4)}, u_{(2,2)}, u_{(3,4)}))$	0.4199
$((u_{(1,2)}, u_{(2,1)}, u_{(3,1)}))$	0.6355	$((u_{(1,3)}, u_{(2,2)}, u_{(3,1)}))$	0.5028	$((u_{(1,4)}, u_{(2,3)}, u_{(3,1)}))$	0.6204
$((u_{(1,2)}, u_{(2,1)}, u_{(3,2)}))$	0.5349	$((u_{(1,3)}, u_{(2,2)}, u_{(3,2)}))$	0.4022	$((u_{(1,4)}, u_{(2,3)}, u_{(3,2)}))$	0.5198
$((u_{(1,2)}, u_{(2,1)}, u_{(3,3)}))$	0.6376	$((u_{(1,3)}, u_{(2,2)}, u_{(3,3)}))$	0.5049	$((u_{(1,4)}, u_{(2,3)}, u_{(3,3)}))$	0.6225
$((u_{(1,2)}, u_{(2,1)}, u_{(3,4)}))$	0.5221	$((u_{(1,3)}, u_{(2,2)}, u_{(3,4)}))$	0.3894	$((u_{(1,4)}, u_{(2,3)}, u_{(3,4)}))$	0.5071





RESEARCH ARTICLE

The Impact of Persian and Central Asian Influence on Kashmiri Art and Architecture: A Study of the Sultanate Period

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ABSTRACT

The art and architecture of Kashmir reflect a blend of influences from various civilizations and cultures that have left their mark on the region over the centuries. During the Sultanate period in Kashmir, there was a significant transformation in both art and architecture, marked by a profound fusion of Persian and Central Asian influences. This era saw the migration of skilled artisans and craftsmen to Kashmir under the patronage of the Sultans, leading to the construction of magnificent palaces, mosques, and tombs. Architectural styles evolved, with a departure from traditional stone constructions in favor of wood and brick, reflecting the influence of Islamic architectural traditions. Alongside architecture, artistic endeavors enriching the cultural fabric of the region. The legacy of the Sultanate era continues to captivate observers, reflecting the creativity, innovation, and cultural diversity of Kashmir's artistic and architectural heritage. This period also underscores the adaptability of architectural styles to local conditions, as evidenced by the widespread use of wood due to its abundance and suitability to the climate. An endeavor has been undertaken to illuminate the profound impact of Persian and Central Asian aesthetics on the artistic and architectural landscape of Kashmir during the Sultanate period.

Keywords: Kashmir, Sultanate Period, Art and Architecture, Transformation, Wooden Style, Brickwork, Uniqueness, Remarkable.





INTRODUCTION

Kashmir often referred to as "Paradise on Earth," is renowned for its stunning natural beauty as well as its rich cultural heritage. The valley of Kashmir has been a land of artistic skill from ancient times. Art and architecture during the reign of the Sultan in Kashmir underwent a profound transformation, guided by a vision to emulate the splendor of Samarqand and Bukhara. To achieve this, the Sultans actively encouraged the immigration of skilled artisans, architects, and craftsmen from Persian and Central Asian regions. This influx of talent led to the emergence of new architectural styles, blending indigenous Kashmiri influences with the sophisticated techniques brought by the migrants. During the Sultanate rule, there was a big construction boom, and many new buildings were built, like palaces, mosques, khanaqahs, and tombs. These buildings showed different styles of architecture. Three main types of architecture from this time still exist today: pure wooden architecture, brick and wood architecture, and pure brick architecture. One notable example of the wooden architecture is the shrine of Shah-e-Hamdan, also known as Khanqah-e-Moula, which stands as one of the oldest Muslim shrines in Kashmir. Similarly, Jamia Masjid, the largest mosque in Kashmir, represents a remarkable fusion of Islamic architectural elements with local craftsmanship, boasting impressive brickwork and towering wooden pillars. The mosque and tomb of Madin Sahib offer further insights into the artistic endeavors of the era, with their colored tile work and exquisite architectural details. The Budshah Tomb, a masterpiece of pure brick architecture, showcases the influence of Persian and Central Asian craftsmanship, reflecting the close diplomatic ties between Sultan Zain-ul-Abidin and the Timurid dynasty. Beyond architecture, the Sultanate era also witnessed flourishing artistic endeavors in painting, calligraphy, bookbinding, and lattice work. Skilled craftsmen from Central Asia imparted their expertise, leading to the development of unique artistic styles that adorned mosques, palaces, and manuscripts. During the Sultanate period, the art and architecture of Kashmir blended different cultural influences to create stunning buildings and artworks that still impress people today. This fusion of styles and ideas resulted in a diverse range of architectural marvels and artistic achievements. The creations of this era continue to fascinate and inspire observers, showcasing the creativity and innovation of Kashmiri craftsmen and artists.

METHODOLOGY

This study employs a multidisciplinary approach, drawing upon historical analysis, architectural documentation, and art historical methodologies to examine the Persian and Central Asian influence on Kashmiri art and architecture during the Sultanate Period. Primary sources including historical texts, inscriptions, and architectural remains are critically analyzed to identify the stylistic features and motifs characteristic of Persian and Central Asian influence. Additionally, comparative analysis with contemporary architectural styles from Persia and Central Asia is conducted to discern the extent of cross-cultural exchange. Furthermore, field surveys and site visits are conducted to document and analyze the architectural elements and decorative motifs present in extant structures in Kashmir. Finally, scholarly literature and secondary sources are consulted to contextualize the findings within the broader historical and cultural framework of the Sultanate Period in Kashmir.

Objectives of the Study

- ❖ To analyze the architectural transformations in Kashmir during the Sultanate era
- ❖ To identify key architectural monuments reflecting Persian and Central Asian influence:
- ❖ To examine artistic endeavors during the Sultanate period
- ❖ To assess the cultural significance of Persian and Central Asian influence on Kashmiri art and architecture

Shrine of Shah-E- Hamdan

The shrine of Shah-e-Hamdan, also known as Khanqah-e-Moula, holds significant historical importance as one of Kashmir's oldest Muslim shrines, situated along the banks of the river Jehlum.. Its historical roots trace back to Sultan Sikander's era (1389-1413 AD), who commissioned its construction in 1395 A.D in honor of Mir Syed Ali Hamdani, a



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revered Muslim preacher credited with propagating Islam in Kashmir. This architectural marvel, the Khanaqah-i-Mualla, erected under Sultan Sikander's patronage, epitomizes the distinctive wooden craftsmanship of the region. Featuring a two-story structure crowned by a majestic pyramidal roof in three tiers, it boasts intricate woodwork that showcases the pinnacle of the Valley's architectural finesse. Standing tall at 125 feet, its steeple, adorned with a graceful finial, overlooks an open pavilion where the muazzin calls to prayer. The design echoes similarities with the wooden edifices found in neighboring lands, particularly China, renowned for its rich tradition of woodworking. This architectural style likely traversed through the vast mountainous terrain from Tibet to Swat, with Muslim preachers from Kashmir adapting and introducing it to the Valley, influenced by their travels and interactions with rulers of the North West Frontier. This adaptation was not only aesthetically pleasing but also well-suited to the climatic conditions of Kashmir, becoming an integral part of its religious architectural landscape.

Jamia Masjid

Jamia Masjid, situated in Nowhatta, Kashmir, is renowned as the largest mosque in the region and holds significant religious importance for Muslims. Its architectural style, massive size, intricate design, and flawless execution exemplify the remarkable achievements of early Islamic art in the valley. The mosque showcases typical Kashmiri wooden architecture, adding to its uniqueness and cultural significance. The Jamia Masjid, constructed under the reign of Sultan Sikandar, stands as a testament to the fervent religious dedication that drove the establishment of Islamic institutions in Kashmir during that era. Its impressive scale, intricate design, and meticulous craftsmanship mark it as one of the foremost achievements of early Islamic art in the region. Following a traditional mosque layout, it features a central courtyard surrounded by arched arcades, adorned with beautiful naves, pyramidal roofs and steeples, jail decorations and minors. Particularly noteworthy is the exceptional quality of the brickwork, showcasing the skill of its builders. However, the true magnificence of the mosque lies in its towering pillars, crafted from single logs reaching heights ranging from 7.6 to 15.2 meters. These pillars, a marvel of construction, lend an air of grandeur and solemnity to the space. Notably, the mosque's construction was overseen by two skilled artisans from Central Asia, Khawaja Sadar-al-Din Khurasani and Sayyid Muhammad Loristani, who accompanied Sayyid Muhammad Hamadani to Kashmir. According to historical accounts Baharistan-i Shahi, the architectural style of the mosque draws influence from regions such as Syria and Egypt, which was later transmitted to Kashmir via Persia and Central Asia through the movement of people. In essence, the Jamia Masjid stands as a testament to the cultural exchange and architectural brilliance that characterized the Islamic civilization's spread across diverse regions, leaving an indelible mark on the landscape of Kashmir.

Mosque and Tomb of Madin Sahib

The Madani Mosque in Srinagar was built in 1444 for Sayyid Muhammad Madani. The Pir of Sultan Zain-ul-Abidin. It has two notable characteristics. The first distinguishing feature is its colourful tile-work, which originated from Persia and differed from the Mughal tile work. The mosque of Madin Sahib in Zadibal is one of the most well-known pre-Mughal Muslim structures in Kashmir. The base is square and constructed solely from materials originating from a plinth of a mediaeval temple. The superstructure comprises four walls decorated externally with trefoiled brick niches. The corner pilasters and niches' pilasters have bases and capitals that exhibit a distinctly Hindu style. The spandrels of the arches that make up the niches are embellished with exquisite tracery work. The cornice above the walls consists of six layers of wood. The cornices below the eaves are constructed with wooden courses, some of which include delicate designs. The chamber has a pyramidal roof made of clay and birchbark. The roof has a pyramidal shape with a spiral apex, now remaining as a single upright pole and few timber parts. The prayer rooms can be reached through a beautifully carved wooden doorway supported by two curved stone columns. Inside the prayer chamber, there is a Khatamband ceiling made of thin pieces of soft wood woven into a geometrical pattern, supported by four multi-sided wooden columns.

The tomb of Madin Sahib, built in the 15th century, is considered one of the most interesting tombs in Srinagar. The structure was built in honour of saint Madin Sahib and is located to the north of the Madin Sahib mosque in Zadibal. Several inscriptions and architectural styles emphasise the historical significance of the era. The walls were formerly adorned with glazed tiles, showcasing a charming 15th-century Kashmir architectural style, but most of them are



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now absent. Some have been preserved in the Srinagar museum. The mosque and tomb had been built during the reign of Zain-ul-Abidin. The most notable aspect of the structure was the depiction of a beast that had the body of a leopard and the trunk of a human being. It appeared to be shooting with a bow and arrow at its own tail, which ended in a head that resembled that of a dragon. In the vicinity, a fox was quietly watching from among the flowers and cloud forms. According to reports, the utilisation of cloud formations and dragon's head shows influences from Chinese and Persian cultures.

The Budshah Tomb

The tomb build by Sultan Zain-ul-Abidin for his mother is considered the outstanding example of pure brick architecture. It is constructed with a unique kind of brick that is mainly Persian and Central Asian in origin. It is noteworthy that the technique of double-dome architecture was originally brought to Central Asia by Timur (1336-1405). Sultan Zain-ul-Abidin maintained close diplomatic ties with the Timurid dynasty, leading to an exchange of gifts between the two rulers. Initially, Sultan Zain-ul-Abidin sought not only material gifts but also desired to acquire knowledge of advanced sciences and technologies from his Central Asian counterpart. This exchange fostered intimate contacts and resulted in the migration of a considerable number of architects, engineers, and masons from Central Asia to the valley of Kashmir. Consequently, the technology of double-domed architecture was introduced to the region much earlier than it appeared in other parts of India, representing a significant contribution to the evolution of building construction techniques in the area. The Budshah Tomb, located in the Zainakadal area along the right bank of the Jehlum River, serves as the final resting place for Sultan Zain-ul-Abidin's mother. Renowned for its architectural splendor, this tomb stands as a remarkable representation of Shalmiri craftsmanship, unique in its use of brick construction—a departure from the prevalent wooden architectural style in Kashmir during that era. The tomb is constructed on a raised stone plinth with a ground plan featuring 16 sides made of Ashlar stone masonry. The tomb consists of four meticulously arranged courses of stone, complemented by a torus cornice that adds to its architectural grandeur. The main construction of the tomb comprises plain horizontal brickwork, which is reinforced with lime and surkhi to enhance durability. However, the faces of the tomb are adorned with pointed arches, providing a distinctive visual appeal. These arches, with the exception of those facing west, exhibit shallow blind detailing. While most of these arches maintain a simplistic design. The incorporation of glazed tiles into the construction of the tomb enhanced its visual appeal, elevating the aesthetic charm of the edifice. Colorful panels of glazed tiles adorned both the exterior and interior surfaces of the building, breaking the monotony of plain brickwork. The earliest examples of glazed tiles from this period are attributed to the reign of Sultan Zain-ul-Abidin. These tiles, consisting of square units in a variety of vibrant hues such as blue, red, brown, green, and yellow on a single piece, added a touch of brilliance to the structure. Additionally, the tiles featured exquisite paintings, further enriching their artistic value. The introduction of glazed tile work is believed to have originated from Persia and Central Asia, where the craft had undergone significant advancement, before being incorporated into the architectural landscape of the tomb. In the whole of Central Asia all the tombs, mosques and palaces built during the medieval period are made of this type of brick.

Rajdan Palace

Sultan Zain-ul-Abidin built a building in the town of Zainanagari, which in the dialect of Kashmir is called Rajdan. This palace, characterized by its brick and wood construction, stood as a testament to the Sultan's vision of architectural magnificence. Surmounted by a lotus-shaped golden dome of singular beauty, the palace boasted an audience hall adorned with extensive walls lined with glass, showcasing the Sultan's penchant for luxury and refinement. Mirza Haidar Dughlat, in his work, vividly describes the grandeur of the palace, noting its towering twelve stories and numerous rooms, halls, and corridors. While the palace has since vanished, its legacy endures through historical accounts, serving as a reminder of Zain-ul-Abidin's reign and his dedication to creating enduring monuments of architectural brilliance. Surrounding the palace, lands were allotted to top army generals and distinguished men of letters, creating a vibrant community that enriched the Sultan's court with their wisdom and expertise. Though the physical remnants of Zainanagari have faded into history, its memory lives on as a testament to the majesty and sophistication of medieval Kashmiri architecture and culture.



**Sarfaraz Ahmad Rather and Rajeshwari****Artistic Endeavors**

Art has long been a vital expression of human creativity and cultural identity, transcending boundaries and enriching societies. The Sultan's profound interest in the advancement of arts and crafts heralded a transformative era in Kashmir's cultural landscape. Through strategic initiatives, they invited skilled artisans from Central Asia, particularly from Tibet, to impart their expertise to their subjects.

Painting

Painting was a favorite art in Persia and Central Asia during the medieval times and it received full state patronage despite the fact that Islam does not sanction it. During the time when Persian and Central Asian cultures were highly esteemed among Muslims, Kashmir also embraced this trend, aspiring to be recognized as part of this sophisticated cultural circle. Despite the absence of surviving paintings, historical records indicate that Kashmir had a rich artistic heritage and distinctive style. Mulla Jamil, a renowned painter, served under Zain-ul-Abidin, showcasing the region's artistic talent. During the Sultan period in Kashmir, patronage of paintings flourished as an integral aspect of cultural expression and royal prestige. Under the benevolent rule of the Sultans, Kashmir became a vibrant center for artistic endeavors, where painters found generous support and encouragement. The Sultans themselves often commissioned exquisite artworks, fostering a culture of artistic patronage that permeated throughout the society. Paintings during this era depicted a rich tapestry of themes, from scenes of courtly life to depictions of the natural beauty of Kashmir's landscapes. Royal palaces and religious institutions became focal points for these artistic endeavors, adorned with intricate frescoes and murals that reflected the artistic prowess of the period. Skilled artisans were revered and attracted to the region, contributing to the refinement and diversification of artistic techniques. The patronage of paintings by the Sultans not only embellished the physical spaces of Kashmir but also served as a means of legitimizing their rule and projecting cultural sophistication. This period witnessed a renaissance of artistic expression, where painters were celebrated as custodians of tradition and innovation alike.

Calligraphy

It's noteworthy that the palaces and grand residences of both Sultans and nobles were adorned with elaborate wall paintings. Describing the mansions of a noble, their living quarters and gathering spaces were enriched with wall paintings displaying exceptional elegance and craftsmanship. The patronage extended by the Sultans to such artworks not only enhanced the physical allure of Kashmir's spaces but also served to legitimize their authority and showcase cultural refinement. This era marked a revival of artistic expression, with painters revered as guardians of both tradition and innovation. During the Sultan period in Kashmir, the art of calligraphy was highly esteemed and practiced extensively. Calligraphy, the decorative handwriting or lettering, was an integral part of Islamic culture, and it flourished under the patronage of the Sultans in Kashmir. Skilled calligraphers produced beautiful manuscripts, inscriptions, and decorative elements for architecture, often using Arabic script.

Timurids, with whom the Sultans of Kashmir had friendly relations, were great patrons of painting, calligraphy and the art of the books. It is during this period that the great painter Mir Ali of Tabriz invented the feminine and dancing scrip known as Nastaliq. As expert calligraphists were required not only for writing books but also for decorating the interior of khanaqahs, mosques, tombs as well as for writing inscriptions, the Sultans, after their Persian and Central Asian counterparts, patronized the art, attracting a number of master calligraphists from different parts of Timurid empire. The art flourished to such an extent that Kashmiri calligraphists were crowned with laurels by the Mughals. Emperor Akbar was so much impressed by the grace, beauty and symmetry of one of the calligraphists of Kashmir, Muhammad Husain that he conferred upon him the title of Zarrin-qalam (Gold-pen). While lauding the extraordinary genius of Muhammad Husain Kashmiri who rivaled Mir Ali, the classical master of calligraphy, Abul Fazl says, "The artist who in the shadow of the throne of His Majesty, has become a master of calligraphy, is Muhammad Husain of Kashmir. He has been honoured with the title Zarin Qalam, the golden pen. He surpassed his master, Maulana Abdal-Aziz; his maddat and dawa'ir show everywhere a proper proportion to each other, and the art critics consider him equal to Mulana Mir Ali. Some mosques, tombs and epitaphs of the period bear Persian and Arabic inscriptions in elegant naskh and nasta'aliq, which further substantiate that the art had reached to a high perfection.



**Sarfaraz Ahmad Rather and Rajeshwari****Book Binding**

During the Sultan period in Kashmir, the art of book binding flourished as skilled craftsmen learned techniques from experts in Central Asia. The Timurids were known to be strong supporters of the art of the book ; in fact, Balsunqur Mirza, the son of Shah Rukh and a wazir at his father's court in Herat, brought together artists from all across the Timurid empire at the academy and library he established at Herat. The papermaker, scribe, illuminator, margin-cutter, color-grinder, painter, and binder collaborated to create some of the finest books ever produced. Calligraphy, illumination, and painting were just parts of the entire book. During the Timurid era, bookbinders demonstrated their proficiency alongside other artisans. Bindings typically consisted of leather wrapped around pasteboard, with intricate decorations adorning both covers and the flap that shielded the pages' front edge. The embellishments applied to these covers employed elaborate techniques, showcasing the binders skill and attention to detail. Impressed by the art of book, especially the art of book binding of the Timurids, Sultan Zain al- Abidin deputed a few intelligent people of Kashmir to Central Asia to learn it at the feet of its experts. Consequently the art got diffused in Kashmir and there came into existence a colony of book binders which has survived to us in the name of *Jilad gar mohalla* (the quarter of book binders) located in old Srinagar.

Lattice work

Pinjari, the intricate lattice work on wood, holds a special place in the rich tradition of Kashmiri craftsmanship. Found adorning fences, doors, railings, ventilators, room partitions, screens, and windows, this art form adds an exquisite touch to the region's architectural landscape. The geometric designs seen in most wooden structures showcase the mastery and attention to detail of Kashmiri artisans. However, the carved lattice scrolls at the Madin Sahib Tomb in Srinagar offer a unique variation, hinting at the evolution of this craft over time. Dating back to the 15th century during the reign of Zain-ul-Abidin, this tomb serves as a testament to the early existence of lattice craftsmanship in the region, paving the way for its widespread adoption in wooden structures. The introduction of this art form may have been spearheaded by Sultan Zain-ul-Abidin himself, known for his patronage of skilled craftsmen from Central Asia. The legacy of Pinjari continues to enchant visitors, showcasing Kashmir's rich cultural heritage and the timeless beauty of its architectural marvels.

CONCLUSION

In conclusion, the influence of Persian and Central Asian cultures on Kashmiri art and architecture during the Sultanate period was profound and far-reaching. This period witnessed a fusion of artistic styles, techniques, and motifs, resulting in the creation of unique and aesthetically rich monuments and artworks. The architectural marvels such as mosques, tombs, and palaces, with their intricate carvings, domes, and minarets, reflect a synthesis of Persian, Central Asian, and indigenous Kashmiri architectural traditions. Similarly, in the realm of art, Persianate elements such as calligraphy, miniature painting, and intricate designs were incorporated into Kashmiri artistic expressions. This cultural exchange not only enriched the artistic landscape of Kashmir but also contributed to the region's socio-cultural and religious identity. Through this manuscript, we can appreciate the enduring legacy of Persian and Central Asian influences on Kashmiri art and architecture, which continue to inspire and fascinate us to this day.

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<p>Fig 1: Shrine of Shah-E-Hamdan or Khanqah-E-Moula</p>	<p>Fig 2: Jamia Masjid</p>
	
<p>Fig 3: Mosque and Tomb of Madin Sahib</p>	<p>Fig 4: The Budshah Tomb</p>
	
<p>Fig 5: Painting</p>	<p>Fig 6: Calligraphy</p>





Delineating Salinity Tolerance Traits in Rice (*Oryza sativa* L.) Germination Stage: Multivariate Analysis for Trait Prioritization and Genotype Selection

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ABSTRACT

The current study evaluated 34 rice genotypes for germination traits under varying levels of salt stress (0 mM, 40 mM, 80 mM, and 120 mM NaCl concentrations). Correlation and principal component analyses were employed to identify promising genotypes and unfold trait associations conferring salinity tolerance. The genotypes G1, G2, G9, G10, G11, G15, G21, G24, G25, G28, G30, G31, and G34 outperformed the check variety for multiple traits. Germination percentage, root length, shoot length, and seedling vigor indices exhibited strong positive correlations, suggesting their potential as selection criteria. Principal component analysis (PCA) revealed traits total seedling length, root length, germination percentage, dry weight, and seedling vigor index II as major contributors to genetic diversity. Biplots consistently highlighted dry weight and seedling vigor index II as primary sources of variation under various saline stress conditions. This study provides insights into trait prioritization and genotype selection during germination for developing salt-tolerant rice varieties.

Keywords: Rice, germination, salinity, correlation, PCA, dry weight





INTRODUCTION

Rice (*Oryza sativa* L.), a momentous cereal crop worldwide, is adaptable to an extensive spectrum of climatic conditions, yet, its yield characteristics are sternly curbed by several abiotic and biotic stresses [1]. Since salinity constitutes a compelling threat to crop yield, hence, attempts to develop salt-tolerant cultivars have become vital in providing food for the millions of mankind residing in such challenging environments [2]. According to [3], rice is considered sensitive to salt, especially in its early stages. The three predominant stages of rice development where salt injury is most evident are germination [4], vegetative and reproductive [5]. The key stage in a plant's life cycle is seed germination, which determines the eventual growth and development levels making it an important stage for screening and selecting stress-tolerant genotypes in breeding programs. Salinity affects seed germination through osmotic stress, ion-specific effects, and oxidative stress, leading to reduced germination rates and prolonged germination time. Excessive sodium and chloride ions can impede embryo viability, enzyme structure, as well as respiration, photosynthesis, and protein synthesis [6]. While several studies [7] [8] claimed that rice was largely saline tolerant during the germination phase, NERICA rice varieties including the 'Pokkali' varieties exhibited salt sensitive responsiveness to germination energy, speed, and percentage [9] [10] [11] reported that in Pakistani, Egyptian, and Iraqi varieties, salt content had a detrimental effect on germination percentage, germination rate, seedling length, and fresh and dry weight. Utilizing salt-affected lands for sustainable rice farming necessitates the identification of salt-tolerant varieties and the introgression of their salt-tolerant trait into high-yielding cultivars [12]. In this regard, the current study was carried out to evaluate the germination stage performance of 34 rice genotypes under four different concentrations of salt solution.

MATERIALS AND METHODS

The current study employing 34 rice genotypes (Table 1) was conducted at the Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University. The check variety used in the study was CSR 37. The experiment was laid out using a Completely Randomized Design (CRD) with three replications. The treatments consisted of four different concentrations of NaCl: 0 mM (control), 40 mM, 80 mM, and 120 mM in which each genotype was subjected to each NaCl treatment in three replications. After five minutes of surface sterilization with a 0.1% mercuric chloride solution, the seeds of all the genotypes were carefully rinsed with distilled water. Ten seeds were set up in Petri dishes that had two layers of germination paper on them that had been poured with the appropriate NaCl solutions. The Petri plates were held under cold white fluorescent light with a 12-hour light/dark cycle in a growth chamber at $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$. The following traits were recorded, after seven days of germination: Germination percentage (%), Root length (cm), Shoot length (SL, cm), Total seedling length (Root length + Shoot length) (cm), Fresh weight (g), Dry weight (g) obtained after oven-drying the seedlings at 65°C for 72 hours, water content (%) = $[(\text{FW} - \text{DW}) / \text{FW}] \times 100$ Number of roots, Sodium (Na^+) content (g/g dry weight), Potassium (K^+) content (g/g dry weight), Sodium-potassium ratio (Na^+/K^+), Seedling vigor index I (SVI-I) = Germination percentage (%) \times Total seedling length and Seedling vigor index II (SVI-II) = Germination percentage (%) \times Dry Weight. Sodium and potassium contents of the entire plant sample (root and shoot combined) were estimated using the tri-acid digestion method (Nitric acid (HNO_3) : Sulfuric acid (H_2SO_4) : Perchloric acid (HClO_4) in the ratio of 9:1:4) followed by flame photometry analysis. The estimated concentration of Na^+ and K^+ were calculated based on the standard curve. Microsoft Excel was used to perform basic mathematical analyses, such as calculating the significance of the mean genotype performance for all traits at the 5% level ($p < 0.05$) using the critical difference. Pearson correlation was calculated at both 5% ($p < 0.05$) and 1% level ($p < 0.01$) among the germination parameters to estimate the association among different traits using Grapesagril software [13]. Principal components were computed using STAR 2.0.1 software (International Rice Research Institute [IRRI], Los Baños, Laguna, Philippines) and XLstat software.





RESULTS AND DISCUSSION

Mean performance

The mean performance of genotypes for all the traits under different treatments are listed in the Table 2a to 2d. To ensure the best possible stand establishment under salinity stress, higher germination percentage is the most important indicator of seed viability and vigor. At 40 mM and 80 mM NaCl concentrations, the genotypes G28 and G29 demonstrated significantly higher germination percentages than the check variety CSR 37, while at 120 mM NaCl, the genotype G15 outperformed the check variety. When exposed to 80 mM and 120 mM NaCl stress, the genotype G1 developed significantly greater root lengths than the check variety while at 40 mM and 120 mM NaCl concentrations, the root lengths of genotypes G28 and G31 were superior which could contribute to better anchorage, nutrient and water uptake under saline conditions.. The genotypes G9, G23, and G29 revealed more significant shoot lengths than the check variety at 40 mM NaCl concentration. The genotype G11 disclosed a significantly greater shoot length against the check variety at 80 mM NaCl. Greater photosynthetic potential and early seedling growth under salinity stress could be indicated by longer shoots. In all the salinity levels, the genotype G28 explained greater total seedling length than CSR 37. Under 80 mM NaCl treatment, the genotype G11 indicated a higher fresh weight than the check variety while at 40 mM and 80 mM NaCl, the genotype G34 established greater fresh weight, while at 120 mM NaCl, the genotype G15 performed better than the check variety.

The genotypes G1, G2, G4, G8, G9, G10, G15, G19, G21, G24, G25, G30, G31, G33, and G34 described higher dry weight than the check under all the NaCl concentrations. In rice breeding initiatives, dry weight is important for evaluating seedling performance and salt tolerance as it is a valuable predictor of overall seedling vigor and stress tolerance mechanisms by offering an integrated assessment of the seedling's capacity to allocate resources towards growth and biomass accumulation under saline stress conditions. Traits such as shoot length, total seedling length, fresh weight and dry weight were also influenced by salinity stress, with genotypes such as G9, G11, G15, G23, G28, G29, and G34 performing better than the check variety. These traits are crucial indicators of early growth, biomass accumulation, and the ability to maintain growth under stress. When compared to the check variety, the genotype G16 confirmed an increased water content. The genotypes G3, G10, G19, and G24 performed better than CSR 37 at all NaCl concentrations for the trait number of roots. In order for a seedling to survive and flourish under salt stress, possession of more roots could be critical to improve its ability to absorb water and nutrients, anchor itself and explore the resources in the soil. For the trait sodium, the genotype G2 performed better than the check variety at all NaCl levels. At 40 mM and 120 mM NaCl, the genotype G28 recorded a larger potassium concentration, while G18, G16 and G29 performed better than the control at 80 mM and 120 mM NaCl, respectively.

At all NaCl levels, the genotype G31 showed a greater Na/K ratio than the check. Rice seedlings could more effectively govern their water relations and ionic homeostasis by sustaining lower Na⁺ and higher K⁺ level which consequently enhances their capacity to tolerate and the negative consequences of salinity stress. Genotypes with higher K⁺ content, lower Na⁺ content, and a favorable Na⁺/K⁺ ratio in saline environments should be given priority in rice breeding programs for additional analysis and possible use as donors to increase salinity tolerance in rice cultivars. Under 80 mM and 120 mM NaCl treatment, the genotype G34 outperformed the check for the trait Seedling Vigor Index I. The genotypes G1, G2, G8, G9, G10, G11, G21, G24, G25, G28, G30, G31 and G34 surpassed the check variety for the trait seedling Vigor Index II at all saline treatments. Similar results and the trend of reduction in the mean performance of the genotypes with increase in the saline concentration were observed by [14], [15], [16] [4], [17] and [18]. Therefore, in rice saline stress breeding initiatives, the genotypes G1, G2, G9, G10, G11, G15, G21, G24, G25, G28, G30, G31 and G34 that outperformed the check variety for various germination traits could be further analyzed and utilized to generate salt-tolerant rice varieties that will thrive in saline-affected locations.



**Sruthi and Anbuselvam****Correlation analysis**

Correlation coefficient aids in finding out the degree and direction of association between traits. The correlogram obtained for various saline treatments are given in Figures 1 to 4. The trait germination percentage at 0mM and 80mM saline treatment exhibited a high significant positive correlation ($p < 0.01$) with total seedling length ($r = 0.698$ and 0.970 , respectively). Similarly, at 40mM and 120mM, a highly significant positive relationship ($p < 0.01$) was observed with the trait seedling vigor index I. Additionally, at all saline treatments, the trait exhibited a significant positive association ($p < 0.05$) with root length and shoot length. The results indicate that under non-stress conditions, seedling growth is the key associated trait, but, as the salt stress spikes, seedling vigor turn into an increasingly important operator of successful germination. During the germination and early seedling stages of plant growth, this understanding may contribute in determining of prospective selection criteria for saline tolerance. This suggests that selecting for high germination percentage could indirectly improve seedling growth and vigor under salt stress. The trait root length at 0 mM and 120 mM exhibited a high significant positive correlation ($p < 0.01$) with total seedling length ($r = 0.955$ and 0.800 , respectively) indicating that longer root length contributes to increased overall seedling length under both non-saline and high salinity conditions. Similarly, at 40mM and 80mM, a highly significant positive association ($p < 0.01$) was observed with the trait seedling vigor index I ($r = 0.864$ and 0.849 , respectively).

Additionally, at all saline treatments, the trait exhibited a significant positive relationship ($p < 0.05$) with germination per cent. The trait shoot length at 0 mM and 120 mM exhibited a high significant positive alliance ($p < 0.01$) with total seedling length ($r = 0.955$ and 0.800 , respectively). Similarly, at 40mM and 80mM, a highly significant positive correlation ($p < 0.01$) was observed with the trait seedling vigor index I ($r = 0.864$ and 0.849 , respectively). Additionally, at all saline treatments, the trait exhibited a significant positive association ($p < 0.05$) with germination per cent. At 0mM, total seedling length had the highest relationship ($p < 0.01$) with root length ($r = 0.955$) while at 40mM, 80mM, and 120mM, total seedling length explained the highest correlation with Seedling Vigour Index I ($r = 0.996$, 0.996 and 0.971 , respectively) and exhibited significant positive association ($p < 0.05$) with germination percentage and shoot length across all saline treatment. The trait fresh weight at 0 mM and 80 mM exhibited a high significant positive alliance ($p < 0.01$) with water content ($r = 0.525$ and 0.541 , respectively). Similarly, at 40mM and 120 mM, a highly significant positive correlation ($p < 0.01$) was observed with the traits number of roots ($r = 0.621$) and germination per cent ($r = 0.460$), respectively. Additionally, at all saline treatments, the trait exhibited a significant positive relationship ($p < 0.05$) with seedling vigour index II suggesting that maintaining high fresh weight under saline conditions could be associated with better water uptake, root development, germination success, and overall seedling vigor. At all the saline treatments, the trait dry weight revealed high significant positive correlation ($p < 0.01$) with seedling vigour index II ($r = 0.995$, 0.951 , 0.952 and 0.933) highlighting its importance as an indicator of seedling vigor under salt stress while a significant positive association ($p < 0.05$) with water content suggests the need for water uptake for dry matter accumulation. The trait water content at 0 mM, 40 mM and 80 mM established a high significant positive relationship with fresh weight ($r = 0.525$, 0.597 and 0.541 , respectively) while a high significant negative correlation ($p < 0.01$) with dry weight ($r = -0.676$) at 120 mM. At 0 mM and 40 mM saline treatment, the trait number of roots unveiled a high significant positive association ($p < 0.01$) with fresh weight ($r = 0.393$ and 0.621 , respectively) while at 80 mM, it was with germination percentage ($r = 0.535$) and at 120 mM, a high significant negative correlation was observed with dry weight ($r = -0.676$).

By taking into account physiological and biochemical traits instead of basically morphological ones for assessment, it could be possible to comprehend the correlations among traits in rice cultivars associated salinity stress tolerance [19]. The trait sodium described a high significant positive correlation with potassium at 0 mM, 80 mM and 120 mM ($r = 0.779$, 1.000 and 0.955 , respectively) while at 40 mM ($r = 0.563$) it was with water content. At all the saline treatments, the trait potassium explained a high significant positive relationship ($p < 0.01$) with sodium ($r = 0.779$, 0.531 , 1.000 and 0.955 , respectively). The trait Na/K ratio demonstrated a high significant negative association ($p < 0.01$) with potassium and seedling vigour index II at 40 mM and 80 mM ($r = -0.479$ and -0.545 , respectively), respectively and significant positive association ($p < 0.05$) with dry weight. The positive correlation between sodium and potassium suggests the involvement of similar transport mechanisms and the need for ion homeostasis under saline conditions. The negative alliance between Na/K ratio and potassium, and SVI-II indicates that maintaining a



**Sruthi and Anbuselvam**

lower Na/K ratio (higher potassium accumulation relative to sodium) could contribute to better seedling vigor under salt stress. At 40 mM, 80 mM and 120 mM saline treatment, the trait seedling vigour index I elucidated high significant positive correlation ($p < 0.01$) with total seedling length ($r = 0.996, 0.996$ and 0.971 , respectively) while a significant positive correlation ($p < 0.05$) was explained with germination percentage, root length, shoot length and number of roots, making it a potentially useful composite trait for selecting salt-tolerant genotypes during the early growth stages. The trait seedling vigour index II exhibited a high significant positive relationship ($p < 0.01$) with dry weight at all the saline treatments ($r = 0.995, 0.951, 0.952$ and 0.933 , respectively) and a significant positive correlation ($p < 0.05$) was recorded with fresh weight, highlighting its importance as an indicator of overall seedling vigor and biomass accumulation under saline conditions. Parallel outcomes were obtained by [20] [21] in germination stage of rice. However, the results obtained align with the findings of [22], [23], [19] and [24] in different growing stages of rice. Under saline stress conditions, there were strong positive correlations observed between Seedling vigor index II and Dry weight, Seedling vigor index I and Total seedling length, Sodium and Potassium, Root length and Total seedling length, and Shoot length and Total seedling length. This indicates that these traits are closely related to each other. Selecting one trait in these pairs is likely to indirectly improve the other correlated trait during the critical germination and early seedling growth stages and could potentially pave way for developing salt-tolerant rice varieties.

Principal Component Analysis

A key method in rice breeding is principal component analysis (PCA), is used to rank genotypes, determine minimal components, identify maximal variability, and evaluate genetic diversity. Contribution, eigenvalues, and proportion of variance of yield and its contributing traits to different principal components for all the treatments are provided in Table 3. An eigenvalue greater than one was observed in the first three principal components at 0 mM while in all other treatments, the first four principal components exhibited eigen values greater than one. This implies that a considerable amount of the total genetic variation among the rice genotypes, across all treatments, was represented by these principal components. These principal components accounted for 68.80% of the cumulative percentage of variance explained in 0 mM, 84.40% in 40 mM, 84.9% in 80 mM, and 79.10% in 120 mM, suggesting that they constituted a significant proportion of the total genetic diversity across the genotypes. Comparable findings were reported by [25]. The contribution of thirteen germination stage traits to the principal components in 0 mM, 40 mM, 80 mM and 120 mM is presented in Table 3. Principal component analysis conducted across various saline treatments identified variations in the contribution of different germination stage parameters to the genetic diversity among the rice genotypes under study. The cut-off limit for the coefficients of the proper vectors was determined using the [26] criterion, wherein traits with coefficient values less than 0.3 were found not to have significant effects on the total variation, and traits with coefficient values greater than 0.3 were treated as having large effects. The traits with high positive loadings on PC1 in 0 mM saline treatment included germination percentage, root length, shoot length, total seedling length, fresh weight, dry weight and seedling vigour index II indicating that under non-saline conditions, most growth traits were positively associated with PC1, explaining better performance. These traits turned out to be positively correlated with the principal component, and as the principal component's value increased, so did the values of the traits with positive loadings and hence such traits on the same PC could be improved simultaneously, as they are positively associated. Conversely, in 40 mM, 80 mM and 120 mM saline treatments, the traits germination percentage, root length and total seedling length exhibited negative loadings on PC 1 indicating that these traits negatively correlated with the principal component. As salinity levels increased, germination percentage, root length, and total seedling length became negatively correlated with PC1, suggesting a detrimental effect of salinity on these traits. The trait dry weight disclosed negative loadings on PC 2 in the saline treatments of 0 mM, 40 mM, and 80 mM, confirming a negative correlation with the principal component. However, the same trait in the saline treatment of 120 mM disclosed positive loading on PC 2, demonstrating a positive correlation with the principal component by exhibiting a complex pattern. The intricate pattern of dry weight revealed the complex linkages and its contributions to genetic diversity under various salt stress levels. It emphasizes how crucial it is to have an extensive understanding of how traits interact to predict genotypic performance in different stress levels. Scree plot elucidated the variation percentage between Eigenvalues and the Principal components (Fig 5 to Fig 8.). In 0 mM saline treatment, PC1 showed a maximum variation of 28.30% with an eigenvalue of 3.675, compared to other PCs. In 40





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mM, 80 mM and 120 mM , PC1 exhibited 41.5%, 39.7% and 32.1% variability with an eigenvalue of 5.393, 5.162 and 4.171, respectively. The present findings accord with previous work by [17]. The greatest variation across the various treatments proved to be most reliably attributed to the first principal component (PC1), emphasizing the importance of PC1 in addressing the entirety of genetic variability. Major contributors included traits such as total seedling length, root length, and germination %. By focusing on genotypes with high scores on PC1, which captured a sizable fraction of the total variability, breeders could identify desirable genotypes with favorable combinations of these traits. These genotypes could be prioritized during selection and used as potential donors in breeding programs to improve rice yield and related components under saline stress.

The PCA biplots for the four distinct saline treatments demonstrating consistent and divergent patterns in the traits that most contribute to genotypic variance are presented in the Figure 9 to 12. Dry weight and seedling vigour index II consistently possessed the longest vectors across all four treatments, implying that these traits were the main cause of genotype divergence. Variation in these traits was also a significant factor in differentiating genotype performance. Based on the angle between the vectors in the biplot, the traits seedling vigour index II and fresh weight were positively correlated with the trait dry weight across all the treatment. By prioritizing dry weight as a selection criterion in saline breeding programs, breeders could identify genotypes with superior biomass accumulation and overall vigor under salt stress conditions. In this context, there was a positive correlation found between the genotype G9 with the characteristic dry weight in 0 mM, 40 mM, and 120 mM, as the genotype G9 showed a greater value for dry weight , whereas the genotype G21 showed a higher value for dry weight in 0 mM, 80 mM, and 120 mM. Concordant findings were documented by [1] in seedling stage of rice. Thus the PCA results provide insights into the relationships between traits, their contributions to genetic diversity, and the performance of genotypes under different salinity levels. This information can guide breeders in selecting promising genotypes and traits for developing salinity-tolerant rice varieties.

CONCLUSION

The evaluation of mean performance revealed several promising genotypes such as G1, G2, G9, G10, G11, G15, G21, G24, G25, G28, G30, G31 and G34 outperforming the check variety CSR 37 for various traits under different salinity levels. The correlation analysis provided insights into the strong relationships among various traits such as germination percentage, root length, shoot length, and seedling vigor indices suggesting their potential as selection criteria for salt tolerance during early growth stages. The principal component analysis revealed that traits such as total seedling length, root length, germination percentage, dry weight, and seedling vigor index II were major contributors to genetic diversity among genotypes across salinity levels. The PCA biplots consistently showed dry weight and seedling vigor index II as the primary sources of genotypic variation, indicating their significance in differentiating genotype performance under saline stress. Hence, this study has illuminated the importance of prioritizing the selection of high-potential genotypes and traits during germination stage for the development of salt-tolerant rice varieties.

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Table 1 . List of genotypes used in the study

CODE	NAME OF THE GENOTYPE	CODE	NAME OF THE GENOTYPE
G1	ADT 36	G18	SEERAGA SAMBA
G2	ADT 37	G19	KALA NAMA
G3	ADT 39	G20	MILAGU SAMBA
G4	ADT 45	G21	MANI SAMBA
G5	ADT 53	G22	MYSORE MALLI
G6	ASD 16	G23	ARCOT KICHILI SAMBA
G7	CO 51	G24	BAVANI
G8	PMK 1	G25	POONKAR
G9	PMK 3	G26	DRR DHAN 58
G10	ANNA R 4	G27	KURUVA
G11	TPS 5	G28	KUTHIRAI VALI SAMBA
G12	AMMAN GOLD	G29	RATHASALI S4
G13	ATHUR KICHILI SAMBA	G30	NAATU BASMATHI
G14	VASANAI SEERAGA SAMBA	G31	SWARNA
G15	THANGA SAMBA	G32	CSR 37
G16	BASMATHI	G33	TRY 3
G17	SWARNA MASURI	G34	CR1009





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Table 2 a . Mean performance of thirty four rice genotypes for the germination traits

GENO TYPE	G%				RL (cm)				SL (cm)				TSL (cm)			
	0m	40	80	120	0m	40	80	120	0m	40	80	120	0m	40	80	120
G1	100	88.0	84.0	68.0	3.9	3.00	3.00	2.50	5.0	4.40	4.00	1.30	8.9	7.40	7.00	3.80
G2	96.	72.0	62.0	60.0	7.8	1.70	0.40	0.10	4.2	2.40	1.90	0.90	12.	4.10	2.30	1.00
G3	96.	84.0	72.0	62.0	6.2	2.90	1.30	0.40	6.8	4.70	2.80	2.00	13.	7.60	4.10	2.40
G4	100	72.0	68.0	64.0	9.8	0.90	0.40	0.40	5.3	4.00	2.80	2.00	15.	4.90	3.20	2.40
G5	100	72.0	62.0	62.0	8.9	0.80	0.10	0.10	5.9	3.20	2.20	2.00	14.	4.00	2.30	2.10
G6	92.	84.0	64.0	62.0	6.0	5.10	1.00	0.70	4.5	3.20	1.50	1.70	10.	8.30	2.50	2.40
G7	96.	80.0	68.0	60.0	6.4	2.20	0.30	0.30	5.7	4.50	2.80	1.50	12.	6.70	3.10	1.80
G8	100	88.0	72.0	64.0	12.	3.80	1.00	0.80	7.5	5.00	3.30	2.00	20.	8.80	4.30	2.80
G9	96.	84.0	68.0	62.0	5.1	1.30	0.70	0.30	8.3	6.50	2.50	2.00	13.	7.80	3.20	2.30
G10	100	84.0	68.0	64.0	10.	2.30	1.00	0.50	6.5	5.00	2.50	2.50	17.	7.30	3.50	3.00
G11	100	84.0	80.0	68.0	9.5	2.60	2.00	1.20	7.5	4.70	4.50	2.50	17.	7.30	6.50	3.70
G12	100	96.0	64.0	62.0	3.1	2.40	1.00	0.70	4.9	5.10	1.50	1.70	8.0	7.50	2.50	2.40
G13	92.	72.0	68.0	60.0	5.4	1.20	0.60	0.30	5.0	3.00	2.80	1.60	10.	4.20	3.40	1.90
G14	100	84.0	72.0	62.0	9.5	2.90	1.10	0.40	5.2	5.00	3.60	1.60	14.	7.90	4.70	2.00
G15	100	72.0	60.0	76.0	9.2	2.20	0.40	0.10	4.7	2.30	1.30	0.70	13.	4.50	1.70	0.80
G16	100	68.0	72.0	60.0	13.	0.80	1.40	0.10	6.2	3.00	3.00	1.60	20.	3.80	4.40	1.70
G17	100	72.0	80.0	68.0	12.	1.40	2.50	1.40	5.5	3.90	3.40	1.90	17.	5.30	5.90	3.30
G18	88.	84.0	72.0	62.0	3.2	2.30	1.40	0.40	4.2	4.70	2.90	1.80	7.4	7.00	4.30	2.20
G19	100	88.0	72.0	64.0	11.	3.40	1.30	0.60	6.5	5.40	3.20	2.10	18.	8.80	4.50	2.70
G20	92.	80.0	68.0	62.0	4.0	2.50	1.30	0.50	5.6	3.90	2.40	1.90	9.6	6.40	3.70	2.40
G21	96.	88.0	72.0	62.0	5.0	4.50	3.00	0.30	8.0	3.50	1.30	2.10	13.	8.00	4.30	2.40
G22	100	76.0	68.0	62.0	10.	2.30	0.30	0.40	6.2	3.40	2.90	1.90	16.	5.70	3.20	2.30
G23	100	92.0	72.0	64.0	12.	3.40	1.70	0.80	5.8	6.00	3.60	1.80	18.	9.40	5.30	2.60
G24	96.	84.0	68.0	62.0	5.4	3.00	0.50	0.60	7.0	4.50	2.90	1.70	12.	7.50	3.40	2.30
G25	96.	80.0	80.0	60.0	4.5	1.80	1.90	0.10	5.4	3.80	4.10	1.60	9.9	5.60	6.00	1.70
G26	92.	88.0	68.0	60.0	3.6	5.40	1.90	0.40	2.2	2.70	2.00	1.50	5.8	8.10	3.90	1.90
G27	100	88.0	62.0	60.0	9.9	5.90	0.50	0.40	5.1	2.50	1.60	0.80	15.	8.40	2.10	1.20
G28	100	96.0	92.0	60.0	13.	8.00	4.90	0.70	5.4	4.00	4.20	0.90	19.	12.0	11.1	1.60
G29	96.	96.0	80.0	72.0	7.4	6.00	2.30	1.70	6.0	6.10	3.50	2.20	13.	12.1	5.80	4.40
G30	96.	88.0	80.0	62.0	4.9	3.60	2.30	1.00	5.7	5.20	3.50	1.10	10.	8.80	5.80	2.10
G31	100	92.0	80.0	62.0	12.	6.70	4.70	1.30	5.4	2.60	1.30	0.90	17.	9.30	6.00	2.20
G34	96.	96.0	72.0	68.0	9.7	9.30	1.80	0.80	5.7	2.80	2.50	2.40	15.	12.1	4.30	3.20
G33	100	72.0	68.0	40.0	15.	1.50	0.80	0.30	6.9	3.50	2.80	1.20	22.	5.00	3.60	1.50
CSR37	100	88	76	72	7.2	2.7	1.8	1.90	6.7	5.3	3.9	3.3	13.	8	5.7	5.2
MEAN	97.	83.2	71.5	62.9	8.2	3.23	1.49	0.70	5.7	4.11	2.79	1.7	13.	7.34	4.34	2.4
CD	1.6	4.12	3.59	2.82	1.7	1.04	0.58	0.27	0.6	0.56	0.44	0.27	1.9	1.12	0.91	0.45

Table 2b. Mean performance of thirty four rice genotypes for the germination traits

GENO TYPE	FW (g)				DW (g)				WC (%)				NR			
	0m	40	80	120	0m	40m	80m	120	0m	40	80	120	0m	40	80	120
G1	0.0	0.05	0.0	0.04	0.02	0.01	0.01	0.01	77.	67.	69.	64.2	10.	9.0	8.0	3.00





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G2	0.0	0.04	0.0	0.02	0.01	0.01	0.01	0.01	78.	56.	57.	54.0	13.	5.0	3.0	1.00
G3	0.0	0.07	0.0	0.03	0.01	0.01	0.01	0.01	81.	82.	67.	63.7	14.	13.	5.0	3.00
G4	0.0	0.03	0.0	0.03	0.01	0.01	0.01	0.01	74.	53.	61.	69.7	10.	8.0	2.0	2.00
G5	0.0	0.03	0.0	0.02	0.01	0.01	0.00	0.00	77.	64.	66.	62.8	10.	4.0	1.0	1.00
G6	0.1	0.06	0.0	0.03	0.02	0.01	0.01	0.01	81.	76.	65.	65.5	16.	8.0	4.0	1.00
G7	0.0	0.04	0.0	0.03	0.01	0.01	0.01	0.00	81.	71.	72.	70.6	11.	9.0	1.0	1.00
G8	0.1	0.09	0.0	0.06	0.02	0.01	0.01	0.01	86.	79.	75.	79.7	12.	7.0	1.0	1.00
G9	0.0	0.07	0.0	0.06	0.02	0.02	0.01	0.01	69.	73.	69.	77.1	11.	8.0	1.0	1.00
G10	0.1	0.09	0.0	0.06	0.02	0.02	0.01	0.01	87.	77.	77.	76.7	18.	15.	5.0	3.00
G11	0.1	0.09	0.0	0.05	0.01	0.01	0.01	0.01	89.	85.	86.	77.2	15.	11.	10.	1.00
G12	0.0	0.05	0.0	0.03	0.01	0.01	0.01	0.01	66.	80.	65.	65.5	11.	9.0	4.0	1.00
G13	0.0	0.04	0.0	0.02	0.01	0.01	0.01	0.01	83.	68.	64.	47.0	19.	6.0	4.0	2.00
G14	0.0	0.06	0.0	0.02	0.00	0.00	0.00	0.00	87.	87.	83.	67.5	15.	12.	5.0	3.0*
G15	0.0	0.05	0.0	0.10	0.01	0.01	0.01	0.01	76.	71.	56.	88.2	7.0	4.0	1.0	1.00
G16	0.1	0.05	0.0	0.03	0.01	0.01	0.00	0.00	87.	74.	90.	98.6	11.	3.0	6.0	1.00
G17	0.0	0.05	0.0	0.03	0.01	0.00	0.00	0.00	85.	83.	80.	96.3	13.	6.0	7.0	3.00
G18	0.0	0.05	0.0	0.02	0.00	0.00	0.00	0.00	90.	86.	80.	77.0	10.	8.0	4.0	3.00
G19	0.1	0.09	0.0	0.04	0.01	0.01	0.01	0.01	85.	85.	74.	74.5	13.	15.	6.0	5.00
G20	0.0	0.05	0.0	0.03	0.01	0.01	0.01	0.00	86.	77.	73.	70.0	7.0	8.0	3.0	3.00
G21	0.1	0.10	0.0	0.04	0.02	0.02	0.02	0.01	79.	77.	62.	54.5	12.	12.	3.0	2.00
G22	0.0	0.05	0.0	0.02	0.00	0.00	0.00	0.00	89.	84.	76.	70.5	13.	8.0	5.0	2.00
G23	0.1	0.07	0.0	0.02	0.01	0.01	0.00	0.00	86.	82.	77.	87.0	8.0	8.0	4.0	2.00
G24	0.1	0.07	0.0	0.04	0.01	0.01	0.01	0.01	82.	75.	57.	63.5	12.	16.	6.0	3.00
G25	0.1	0.08	0.0	0.03	0.02	0.02	0.02	0.01	79.	72.	74.	41.0	10.	8.0	3.0	1.00
G26	0.0	0.06	0.0	0.02	0.00	0.00	0.00	0.00	80.	85.	78.	59.5	3.0	10.	3.0	2.00
G27	0.0	0.05	0.0	0.02	0.01	0.01	0.01	0.01	83.	75.	61.	47.0	8.0	5.0	2.0	1.00
G28	0.1	0.08	0.0	0.02	0.01	0.01	0.01	0.00	82.	78.	69.	94.2	12.	8.0	5.0	1.00
G29	0.1	0.06	0.0	0.04	0.01	0.01	0.00	0.00	85.	82.	80.	78.2	14.	11.	5.0	4.0*
G30	0.0	0.05	0.0	0.03	0.01	0.01	0.01	0.01	70.	65.	58.	59.0	13.	12.	4.0	2.00
G31	0.1	0.07	0.0	0.03	0.01	0.01	0.01	0.01	83.	76.	71.	57.0	10.	7.0	6.0	2.00
G34	0.0	0.15	0.0	0.04	0.01	0.01	0.01	0.01	81.	90.	87.	72.7	19.	16.	1.0	1.00
G33	0.0	0.04	0.0	0.04	0.02	0.01	0.01	0.01	71.	55.	63.	56.0	12.	3.0	2.0	1.00
CSR 37	0.1	0.12	0.0	0.06	0.01	0.01	0.01	0.00	90.	91.	86.	89.5	15.	11.	2.0	2.00
MEAN	0.0	0.07	0.0	0.03	0.02	0.01	0.01	0.01	81.	76.	71.	69.9	11.	8.9	3.8	1.9
CD	0.0	0.01	0.0	0.00	0.00	0.00	0.00	0.00	3.0	4.6	4.5	7.13	1.7	1.7	1.0	0.52

Table 2c. Mean performance of thirty four rice genotypes for the germination traits

GENO TYPE	Na (g/g)				K (g/g)				Na/K			
	0mM	40m M	80m M	120m M	0mM	40m M	80m M	120m M	0mM	40m M	80m M	120m M
G1	0.003770*	0.007692	0.0081523*	0.0063835	0.0067640*	0.0033706*	0.0032914	0.002068	0.557392*	2.2821577	2.4768612*	3.0868545
G2	0.005070*	0.003959*	0.0039000*	0.0026374*	0.0037478	0.0018391	0.0014353	0.0004725	1.352668*	2.153125	2.7172131	5.5813953
G3	0.004353*	0.010920	0.0060211*	0.0057222	0.0056638	0.0029444	0.0015141	0.0013254	0.768645*	3.7088949	3.9767442	4.3173653





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G4	0.005 388*	0.0048 99	0.0044 637*	0.0058 394	0.0030 68	0.0025 542	0.0015 363	0.0015 255	1.756 329*	1.9174 528	2.9054 545	3.8277 512
G5	0.005 323*	0.0052 15	0.0053 730*	0.0057 563	0.0036 344	0.0024 409	0.0016 429	0.0013 109	1.464 497*	2.1365 639	3.2705 314	4.3910 256
G6	0.005 277*	0.0083 74	0.0035 920*	0.0076 377	0.0033 851	0.0034 959*	0.0012 09	0.0010 58	1.558 882*	2.3953 488	2.9711 934	7.2191 781
G7	0.008 447	0.0060 68	0.0062 538*	0.0078 654	0.0033 409	0.0017 273	0.0016 077	0.0009 423	2.528 345	3.5131 579	3.8899 522	8.3469 388
G8	0.005 007*	0.0046 04	0.0045 773*	0.0062 727	0.0077 778*	0.0022 178	0.0019 227	0.0004 141	0.643 810*	2.0758 929	2.3806 971*	15.146 3415
G9	0.003 686*	0.0053 40	0.0086 715*	0.0037 854	0.0045 128	0.0015 02	0.0023 066	0.0009 659	0.816 761*	3.5552 561	3.7594 937	3.9191 919
G10	0.006 375*	0.0079 06	0.0039 835*	0.0047 488	0.0055 694	0.0035 882*	0.0015 844	0.0014 089	1.144 638*	2.2032 787	2.5142 857*	3.3706 294
G11	0.006 057*	0.0091 304	0.0119 123*	0.0064 057	0.0036 748	0.0036 232*	0.0044 211	0.0015 029	1.648 230*	2.52	2.6944 444	4.2623 574
G12	0.003 860*	0.0062 162	0.0035 920*	0.0076 377	0.0020 841	0.0018 288	0.0012 09	0.0010 58	1.852 018*	3.3990 148	2.9711 934	7.2191 781
G13	0.005 264*	0.0064 094	0.0076 389*	0.0064 122	0.0058 302*	0.0026 772	0.0029 63	0.0010 84	0.902 913*	2.3941 176	2.5781 25	5.9154 93
G14	0.011 309	0.0101 846	0.0095 867*	0.0101 494	0.0079 853*	0.0033 846*	0.0024 533	0.0017 471	1.416 206*	3.0090 909	3.9076 087	5.8092 105
G15	0.007 155*	0.0062 542	0.0050 229*	0.0049 08	0.0031 831	0.0017 119	0.0010 305	0.0006 442	2.247 788	3.6534 653	4.8740 741	7.6190 476
G16	0.009 217	0.0048 971	0.0009 398*	0.0690 00	0.0124 500*	0.0016 25	0.0002 633	0.0177 500*	0.740 295*	3.0135 747	3.5697 329	3.8873 239
G17	0.022 273	0.0078 35	0.0040 811*	0.0127 375	0.0128 182*	0.0028 155	0.0011 892	0.0030 25	1.737 589*	2.7827 586	3.4318 182	4.2107 438
G18	0.009 109	0.0132 759	1.4500 000	0.0097 534	0.0084 348*	0.0029 828	0.3083 333*	0.0017 671	1.079 897*	4.4508 671	4.7027 027	5.5193 798
G19	0.000 020*	0.0110 392	0.0074 567*	0.0076 575	0.0000 97	0.0058 922*	0.0026 693	0.0023 562	0.206 186*	1.8735 441	2.7935 103	3.25
G20	0.004 944*	0.0081 25	0.0086 286*	0.0134 098	0.0044 667	0.0024 375	0.0024 381	0.0026 721	1.106 965*	3.3333 333	3.5390 625	5.0184 049
G21	0.001 842*	0.0087 143	0.0034 598*	0.0066 637	0.0033 289	0.0062 692*	0.0018 851	0.0022 735	0.553 360*	1.3900 088*	1.8353 659*	2.9309 665
G22	0.009 593	0.0072 069	0.0085 286*	0.0149 091	0.0078 475*	0.0032 069*	0.0029 571	0.0023 247	1.222 462*	2.2473 118	2.8840 58	6.4134 078
G23	0.006 731*	0.0065 344	0.0122 637*	0.0110 41	0.0058 077*	0.0030 534*	0.0028 571	0.0018 443	1.158 940*	2.14	4.2923 077	5.9866 667
G24	0.000 822*	0.0010 229*	0.0046 383*	0.0160 174	0.0004 658	0.0005 371	0.0017 872	0.0018 605	1.764 706*	1.9042 553	2.5952 381	8.6093 75
G25	0.002 119*	0.0043 348*	0.0070 226*	0.0076 553	0.0030 78	0.0022 217	0.0031 412	0.0022 67	0.688 525*	1.9511 202	2.2356 115*	3.3768 737
G26	0.002 012*	0.0107 126	0.0088 646*	0.0146 292	0.0009 506	0.0015 977	0.0011 563	0.0014 045	2.116 883	6.7050 36	7.6666 667	10.416
G27	0.005 575*	0.0046 489	0.0064 194*	0.0083 932	0.0040 755	0.0022 672	0.0017 742	0.0021 538	1.368 056*	2.0505 051	3.6181 818	3.8968 254





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G28	0.004 431*	0.0089 259	0.0096 225*	0.0113 41	0.0046 724	0.0030 370*	0.0033 113	0.0043 064*	0.948 339*	2.9390 244	2.906	2.6335 570*
G29	0.004 943*	0.0065 563	0.0123 535*	0.0145 747	0.0036 476	0.0017 465	0.0053 636	0.0045 977*	1.355 091*	3.7540 323	2.3032 015*	3.17
G30	0.002 744*	0.0051 87	0.0077 471*	0.0089 341	0.0027 5	0.0046 585*	0.0040 057	0.0030 599	0.997 980*	1.1134 380*	1.9340 029*	2.9197 652
G31	0.007 890	0.0076 564	0.0053 000*	0.0049 38	0.0055 517	0.0053 374*	0.0030 059	0.0025 814	1.421 118*	1.4344 828*	1.7632 094*	1.9129 129*
G34	0.005 908*	0.006	0.0154 194*	0.0084 404	0.0033 75	0.0019 308	0.0048 548	0.0023 761	1.750 487*	3.1074 919	3.1760 797	3.5521 236
G33	0.001 481*	0.0031 700*	0.0046 800*	0.0052 577	0.0004 972	0.001	0.0010 85	0.0012 165	2.977 778	3.17	4.3133 641	4.3220 339
CSR 37	0.009 543	0.0057 5	0.0081 88	0.0087 94	0.0043 71	0.0024 56	0.0026 56	0.0021 12	2.183 007	2.3413 17	3.0823 53	4.1637 17
MEAN	0.005 8	0.0069	0.0494	0.0102	0.0046 7	0.0028	0.0113	0.0023	1.35	2.72	3.25	5.2
CD (5%)	0.001 9	0.0012 8	0.1258	0.0055	0.0014	0.0006	0.0266	0.0014	0.302 7	0.5309	0.5631	1.3125

Table 2d. Mean performance of thirty four rice genotypes for the germination traits

GENOTYPE	SV I				SVII			
	0mM	40mM	80mM	120mM	0mM	40mM	80mM	120mM
G1	890.00	651.20	588.00*	258.40	2.06*	1.43*	1.27*	0.972*
G2	1152.00	295.20	142.60	60.00	1.75*	1.25*	1.05*	0.69*
G3	1248.00	638.40	295.20	148.80	1.36	1.058	0.91	0.719*
G4	1510.00	352.80	217.60	240.00	1.79*	1.20*	0.93	1.03*
G5	1480.00	288.00	142.60	130.20	1.26	0.86	0.58	0.58
G6	966.00	697.20	160.00	148.80	1.85*	1.24*	0.88	0.76*
G7	1161.60	536.00	210.80	108.00	1.27	1.04	0.71	0.53
G8	2000.00	774.40	309.60	179.20	2.02*	1.74*	1.40*	0.86*
G9	1286.40	655.20	217.60	142.60	2.37*	1.72*	1.06*	0.85*
G10	1700.00	613.20	238.00	192.00	2.43*	1.71*	1.16*	0.92*
G11	1700.00	613.20	520.00	251.60	1.75*	1.16*	0.98*	0.78*
G12	800.00	720.00	160.00	148.80	1.39	1.07	0.88	0.76*
G13	956.80	302.40	231.20	114.00	1.21	0.91	0.73	0.64*
G14	1470.00	663.60	338.40	124.00	0.87	0.63	0.49	0.40
G15	9670.00*	324.00	102.00	60.80	1.63*	1.02	0.79	0.89*
G16	2010.00	258.40	316.80	102.00	1.36	0.87	0.43	0.02
G17	1750.00	381.60	472.00	224.40	1.03	0.61	0.64	0.07
G18	651.20	588.00	309.60	136.40	0.64	0.55	0.42	0.29
G19	1800.00	774.40	324.00	172.80	1.46	1.18*	0.91	0.65*
G20	883.20	512.00	251.60	148.80	1.12	0.90	0.71	0.56
G21	1248.00	704.00	309.60	148.80	2.51*	2.01*	1.61*	1.13*
G22	1640.00	433.20	217.60	142.60	0.87	0.59	0.48	0.37
G23	1800.00	864.80*	381.60	166.40	1.31	1.12	0.66	0.17
G24	1190.40	630.00	231.20	142.60	1.80*	1.47*	1.17*	0.91*
G25	950.40	448.00	480.00	102.00	2.12*	1.74*	1.65*	1.06*





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G26	533.60	712.800	265.20	114.00	0.88	0.78	0.59	0.49
G27	1500.00	739.2.00	130.20	72.00	1.31	1.09	0.73	0.64*
G28	1910.00	1152.00*	1021.20*	96.00	1.89*	1.66*	1.39*	0.07
G29	1286.40	1161.60*	464.00	316.80	1.36	1.01	0.79	0.63
G30	1017.60	774.40	464.00	130.20	1.73*	1.53*	1.34*	0.76*
G31	1740.00	855.60	480.00	136.40	1.70*	1.50*	1.16*	0.80*
G34	2210.00	360.00	244.80	60.00	2.00*	1.40*	1.23*	0.70*
G33	1478.40	1161.60*	309.60	217.60	1.53*	1.46*	0.90	0.74*
CSR 37 (Check)	1390.00	704.00	433.20	374.40	1.28	0.94	0.79	0.49
MEAN	1617.06	627.66	322.94	156.2	1.56	1.19	0.92	0.6
CD (5%)	753.49307	122.7531	88.62336	35.3893	0.23460	0.190061	0.16567	0.1427

*Significant at 5% level ; G% - Germination percentage, RL – Root length, SL – Shoot length, TSL – total seedling length, FW- fresh weight, DW- dry weight, WC – Water content, NR – number of roots, Na – Sodium, K – Potassium, Na/K – Sodium Potassium ratio, SV I – Seedling vigour index I and SV II – Seedling vigour index II.

Table 3. Contribution, Eigen values and proportion of variance of yield and its contributing traits to different principal components

Treatment	0mM			40mM				80mM				120 mM			
	PC1	PC2	PC3	PC1	PC2	PC3	PC4	PC1	PC2	PC3	PC4	PC1	PC2	PC3	PC4
G%	0.33 3	0.15 1	- 0.33 5	- 0.40 0	0.00 0	0.11 5	- 0.01 3	- 0.42 6	0.07 9	- 0.04 7	0.09 5	- 0.34 1	0.07 1	0.26 2	0.04 5
RL	0.34 7	0.28 9	- 0.25 3	- 0.34 1	- 0.01 4	0.27 3	0.45 0	- 0.36 3	0.01 2	- 0.13 9	0.22 2	- 0.36 6	0.10 2	- 0.18 9	0.02 6
SL	0.39 2	- 0.07 9	0.11 6	- 0.17 5	0.02 1	0.17 0	- 0.74 2	- 0.30 6	0.16 7	0.16 0	- 0.13 0	- 0.35 0	0.09 7	0.01 9	- 0.04 1
TSL	0.42 4	0.22 9	- 0.18 6	- 0.40 8	- 0.00 2	0.16 7	0.03 7	- 0.42 1	0.09 0	- 0.03 1	0.12 8	- 0.45 4	0.12 2	- 0.11 6	- 0.01 6
FW	0.36 9	- 0.01 6	0.33 4	- 0.32 5	- 0.11 6	0.00 2	- 0.07 4	- 0.24 0	0.10 9	0.16 0	- 0.69 3	- 0.14 6	0.23 6	0.57 4	- 0.26 8
DW	0.32 0	- 0.39 9	0.02 5	- 0.03 2	- 0.54 8	0.02 1	- 0.01 7	- 0.09 8	0.48 8	- 0.29 0	- 0.18 0	0.15 9	0.45 3	- 0.01 4	- 0.36 3
WC	0.06 3	0.36 2	0.36 6	- 0.28 7	0.33 4	0.08 4	- 0.07 8	- 0.16 6	0.35 5	0.33 7	- 0.43 5	- 0.30 0	- 0.27 8	0.37 0	0.08 6
NR	0.21 0	0.04 0	0.30 9	- 0.30 9	- 0.01 4	0.18 8	- 0.29 1	- 0.24 6	0.14 6	0.10 2	0.31 2	- 0.23 0	0.02 4	- 0.38 3	0.14 3
Na	- 0.01	0.47 1	0.02 8	- 0.15	0.37 1	- 0.39	0.19 6	0.04 3	0.38 1	- 0.55	- 0.17	- 0.05	- 0.44	0.08 6	- 0.41





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	7			9		3				7	8	0	5		0
K	0.05 9	0.40 8	0.23 8	- 0.16 5	- 0.07 1	- 0.68 4	0.32 4	0.03 9	0.38 0	- 0.55 9	- 0.17 9	- 0.07 3	- 0.42 8	- 0.00 3	- 0.52 8
Na/K	- 0.11 4	0.07 3	- 0.43 8	- 0.00 1	0.40 6	0.39 5	- 0.06 2	0.19 2	0.28 3	0.10 1	0.04 4	0.08 7	0.03 8	0.50 2	0.42 7
SV I	0.11 0	0.08 2	- 0.43 0	- 0.40 7	- 0.00 4	0.18 3	0.04 7	- 0.41 6	0.07 5	- 0.04 8	0.16 1	- 0.45 8	0.12 6	- 0.08 5	- 0.02 7
SV II	0.34 6	- 0.37 7	- 0.00 7	- 0.15 5	- 0.51 6	0.03 4	- 0.00 2	- 0.21 8	- 0.42 9	- 0.28 6	- 0.13 2	0.07 7	0.47 2	0.05 1	- 0.36 7
Eigen value	3.67 5	3.22 0	2.04 8	5.39 3	2.92 2	1.44 4	1.20 8	5.16 2	3.09 3	1.59 8	1.18 2	4.17 1	3.40 5	1.54 4	1.16 5
% of variance	0.28 3	0.24 8	0.15 8	0.41 5	0.22 5	0.11 1	0.09 3	0.39 7	0.23 8	0.12 3	0.09 1	0.32 1	0.26 2	0.11 9	0.09 0
Cum % of variance	0.28 3	0.53 0	0.68 8	0.41 5	0.64 0	0.75 1	0.84 4	0.39 7	0.63 5	0.75 8	0.84 9	0.32 1	0.58 3	0.70 2	0.79 1
<p>G% - Germination percentage, RL – Root length, SL – Shoot length, TSL – total seedling length, FW- fresh weight, DW- dry weight, WC – Water content, NR – number of roots, Na – Sodium, K – Potassium, Na/K – Sodium Potassium ratio, SV I – Seedling vigour index I and SV II – Seedling vigour index II.</p>															

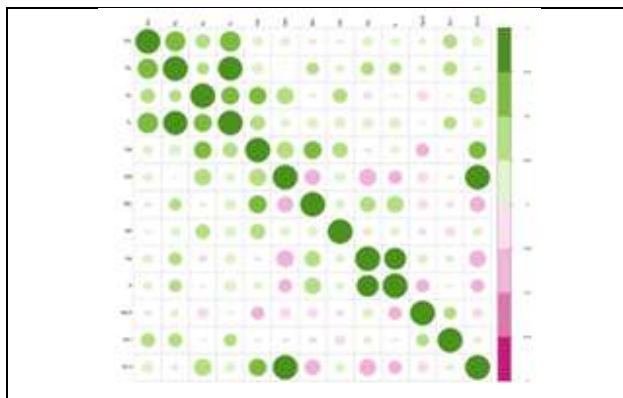


Fig.1. Correlogram depicting correlation among the germination traits at 0mM saline treatment

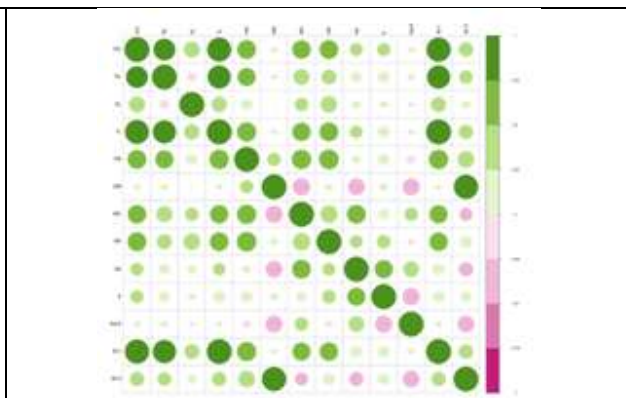
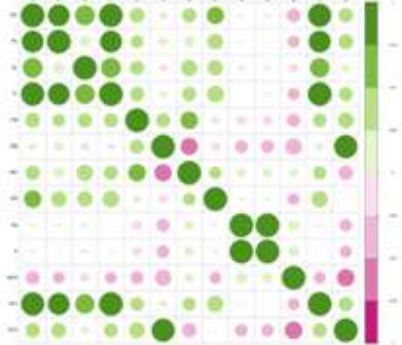
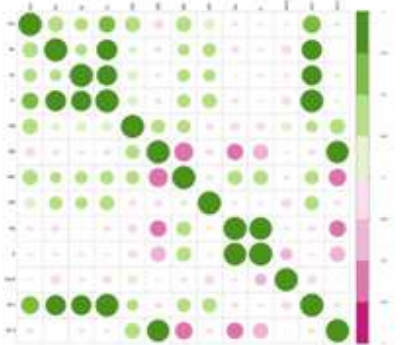
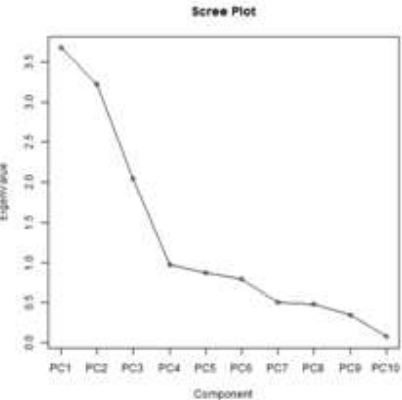
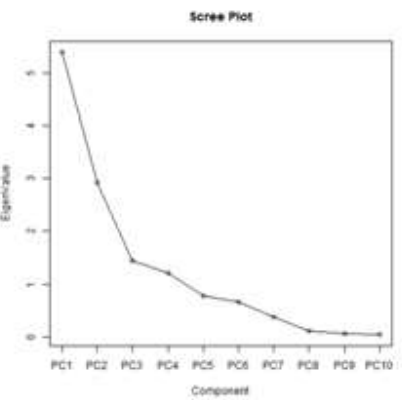
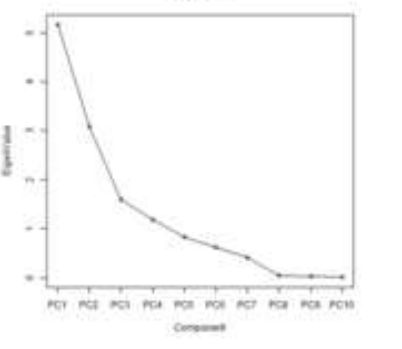
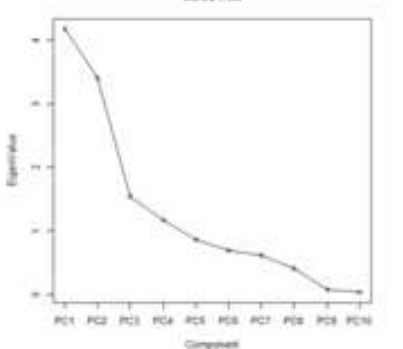


Fig.2. Correlogram depicting correlation among the germination traits at 40mM saline treatment





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<p>Fig.3. Correlogram depicting correlation among the germination traits at 80mM saline treatment</p>	<p>Fig.4. Correlogram depicting correlation among the germination traits at 120mM saline treatment</p>
	
<p>Fig. 5. Screeplot using principal components at 0mM saline treatment</p>	<p>Fig. 6. Screeplot using principal components at of 40mM saline treatment.</p>
	
<p>Fig. 7. Screeplot using principal components at 80mM saline treatment</p>	<p>Fig. 8. Screeplot using principal components at 120mM saline treatment</p>





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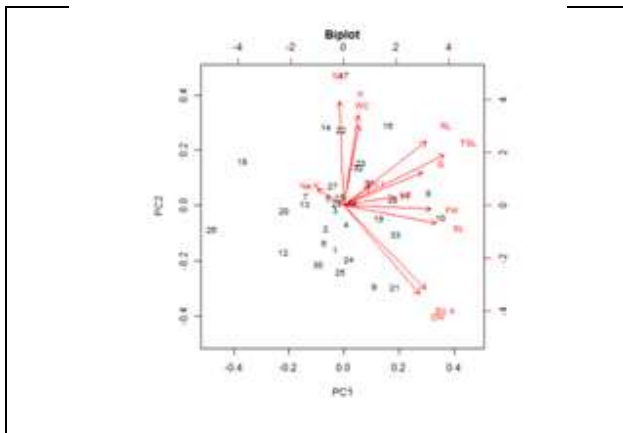


Fig. 9. Biplot diagram of principal components 1 and 2 at 0mM saline treatment

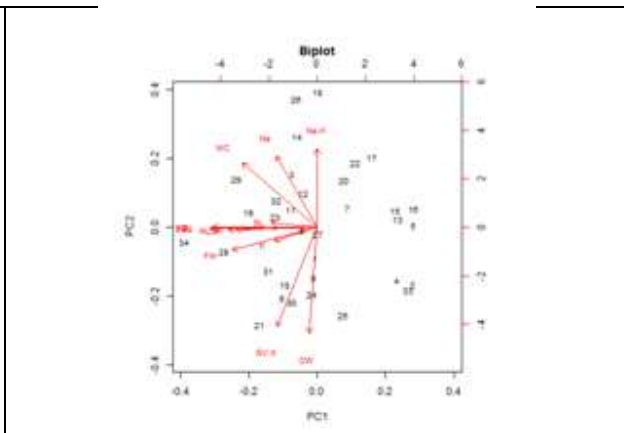


Fig. 10. Biplot diagram of principal components 1 and 2 at 40mM saline treatment

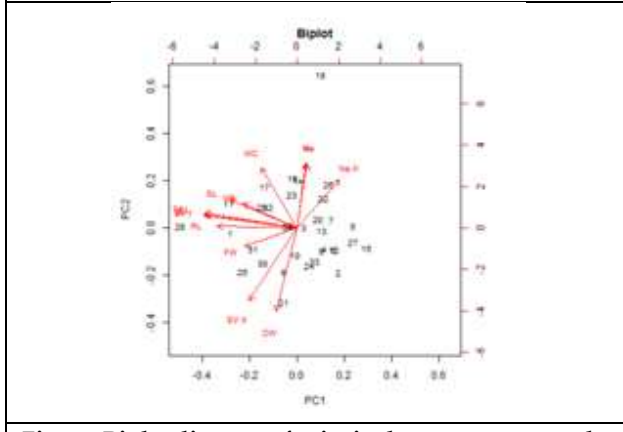


Fig. 11. Biplot diagram of principal components 1 and 2 at 80mM saline treatment

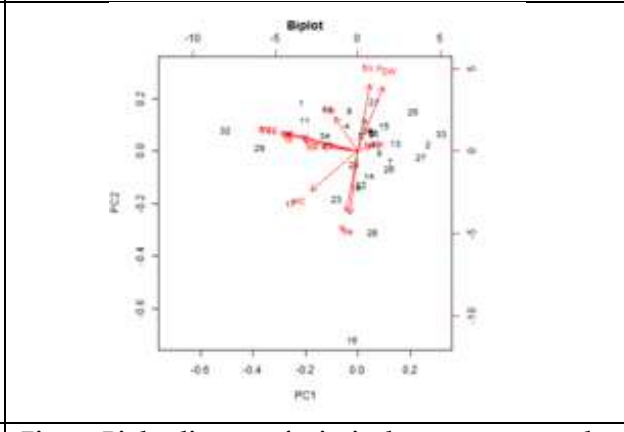


Fig. 12. Biplot diagram of principal components 1 and 2 at 120mM saline treatment





Knowledge and Practice of Breast Feeding among Primi Mothers in a View to Develop Information Booklet in a Selected Hospital, Morigaon District, Assam

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ABSTRACT

The first year of life of the baby is crucial in laying the foundation of good health. Breastfeeding is the ideal method suited for the psychological and physiological needs of the infant. Breast feeding provides numerous health benefits to both the mother and infant. Breast milk remains as ideal nutritional source for the infant, it is also an integral part of the reproductive process with important implications for the health of mothers. The main purpose of the study isto assess the knowledge and practice of breast feeding among primi mothers in a selected hospital Assam.A non-experimental descriptive research approach was adopted for the study. the study was conducted in postnatal wards of Morigaon civil hospital, district, Assam. the knowledge of fifty-four primi mothers were assessed using structured knowledge questionnaire regarding breast feeding, and the practice regarding breastfeeding were assessed by using observational checklist. The major finding of the study revealed that (75.93%) primi mothers had moderate knowledge (24.07%) had an adequate knowledge, and (74.07%) had a good practice whereas (25.93%) had a poor practice regarding breast feeding. The present study concluded that the level of knowledge of primi mothers regarding breastfeeding was moderate on the basis of findings. it is recommended that a similar study can be replicated in another setting. it is also recommending that effectiveness of self-instructional module can be assessed.

Keywords: Knowledge, practice, breast feeding, primi mothers, information booklet





INTRODUCTION

Breastfeeding is the “Gold Standard” for infant feeding. There are several areas of biological superiority of breastfeeding and breast milk over artificial (formula) milk. Obstetricians and midwives should educate the mother during prenatal and postnatal care for the usefulness of breast feeding[1]. World Health Organization (WHO) recognizes breast milk as the best nutritional food source for infants, which should be available to babies deprived of their mother's milk. WHO and UNICEF recommend that breastfeeding should commence within one hour of the child's birth, it should be administered during the first six months of the child's life and should ideally continue till the age of two to ensure the healthy growth and development of the child apart from reducing the rate of child mortality[2]. Although breastfeeding is the "gold standard," not all women breastfeed their infants. According to UNICEF's State of the World's Children Report 2011, of the 136.7 million babies born worldwide each year, only 32.6% are breastfed exclusively for the first 6 months. Some mothers make the choice not to breastfeed, but others might be unable to breastfeed because of medical conditions, such as HIV, or other reasons, such as problems producing milk[3].

OBJECTIVE OF THE STUDY

1. To assess the knowledge of breast feeding among primi mothers
2. To assess the practice of breast feeding among primi mothers
3. To determine the association between the knowledge of breast feeding among primi mothers with selected demographic variables
4. To determine the association between the practice of breast feeding among primi mothers with selected demographic variables
5. To determine the correlation between the knowledge and practice of breast feeding among primi mothers

MATERIALS AND METHOD

A non-experimental descriptive research approach was adopted for the study. The study was conducted in postnatal wards of Morigaon civil hospital, district, Assam among 54 primi mothers. Ethical clearance certificate and formal permission was taken from the concerned authorities and participants to conduct the research study. The tools used for the study was demographic variable, structured knowledge questionnaire and observational checklist. Non-probability Purposive sampling technique was used for selecting the primi mothers who had normal vaginal delivery. The knowledge of fifty-four primi mothers were assessed using structured knowledge questionnaire, and the practice regarding breastfeeding were assessed by using observational checklist. The data obtained were analysed in terms of objective of the study by using descriptive and inferential statistics.

Inclusion criteria

The study includes those Primi mothers

- who were available at the time of data collection.
- who are willing to participate in the study.
- who can understand and write Assamese.

Exclusion criteria

The study excludes those primi mothers

- With Postpartum complications
- who had a baby with any complication after birth.
- who undergone Caesarean delivery.





RESULT

With reference to the sample characteristics presented in Table 1, most of the primi mothers, 44.4% (24) belongs to the age group between 21–26 years, 38.9% (21) had a primary education, 75.9% (41) were unemployed, 40.7% (22) had a family income of 10,002 – 29,972 per month, 61.1% (33) belongs to rural area and majority of the primi mothers 63.0% (34) had received an information regarding breast feeding through health personnel. With reference to the knowledge presented in fig1, majority 75.93% (41) of the primi mothers had moderate knowledge, 24.07% (12) had an adequate knowledge regarding breast feeding and none of the participant falls under inadequate knowledge. With reference to the practice presented in fig 2, it replicates that 74.07% (40) of the primi mothers had a good practice whereas 25.93% (14) had poor practice regarding breast feeding. With reference to the association on level of knowledge regarding breast feeding among primi mothers with the selected demographic variables, the analysis presented in Table 2 showed that there was a significant association found between knowledge of primi mothers with selected demographic variables viz. education of the participant. Hence the research hypotheses were accepted and null hypotheses were rejected. With reference to the association on level of practice regarding breast feeding among primi mothers with the selected demographic variables, the analysis presented in Table 3 showed that there was a significant association found between practice of primi mothers with education of the participant regarding breast feeding. Hence the null hypotheses were rejected, and research hypotheses was accepted in terms of education of participant. With reference to the correlation between level of knowledge and practice regarding breast feeding among primi mothers. The analysis presented in Table 4 showed a significant correlation ($r = 0.462$ at $p < 0.001$) So, the null hypotheses is rejected, and research hypotheses is accepted which implies that there is a moderate positive correlation between level of knowledge and practice regarding breast feeding.

DISCUSSION

The findings of the study have been discussed with reference to the objective, hypotheses, and findings from other studies.

To assess the knowledge of breast feeding among primi mothers in a selected hospitals

In the present study, the knowledge of the primi mothers regarding breast feeding was assessed by administering structured knowledge questionnaire. The result reveals that 75.93% primi mothers had a moderate knowledge and 24.07% had adequate knowledge regarding breast feeding. The study is supported by a cross-sectional study conducted by **Mohite RV, et.al., (2012)** at Krishna Hospital and Medical Research Center, Karad district Satara. The objective of the study is to assess the knowledge of breast feeding among primi- gravida mothers and to determine the association between socio-demographic variables with their knowledge. Hospital based cross sectional study was conducted in Krishna Hospital and Medical Research Center, Karad district Satara among 590 married primi gravid mothers attending anti-natal clinic during study period by utilizing personal interview method pre-tested structured proforma to collect information. Out of 590 primi gravida mothers, 59.66% showed fair quality of knowledge about breast feeding. knowledge about rooming in, family support for breast feeding & burping after breast feeding was 97.7%, 95.4%, 93.5% however weaning, colostrums feed, hazards of bottle feeding and prelactal food was 84%, 82.7%, 75.5% and 54% respectively. Statistical association was existed between age, education, religion, socio-economic status & occupation of respondents with their knowledge about breast feeding. The knowledge of breast feeding among primi gravida mothers attending ANC clinic was of fair in quality ⁴

To assess the practice of breast feeding among primi mothers in a selected hospitals

In the present study, the practice of the primi mothers regarding breast feeding was observed by observational checklist. The result reveals that 74.07% had a good practice and 25.93% had a poor practice regarding breast feeding. It is supported by a descriptive study conducted by **Rani U and Bhattacharjee T (2018)** A study to assess the knowledge and practice regarding techniques of breast feeding among primipara mothers in selected hospital of Delhi with a view to develop self-instructional module. The purpose of this study is to assess the knowledge and



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practice of primipara mothers regarding breast feeding technique with a view to develop self-instructional module. According to the Objectives of the study the data collected by from sample who met sampling criteria by using non-probability convenient sampling. The knowledge and practice were assessed by using breastfeeding knowledge questionnaire, infant feeding and breast-feeding practice checklist respectively the present pilot study was carried out among 20 primipara mothers. The study revealed that the knowledge of primipara mothers regarding breastfeeding was not adequate and that was reflected on their practice of breastfeeding. Primary care givers need to implement strategies to educate primi mothers about breastfeeding to enhance good breastfeeding practice thereby reducing infant mortality and morbidity[5].

To find out the association between knowledge of breast feeding among primi mothers with the selected demographic variables

The present study reveals that there is significant association between knowledge of breast feeding among primi mothers with demographic variables for education of the participant $\chi^2=8.609$ at significant level of $p < 0.05$

The present study is supported by a cross- sectional study conducted by **Habibi M, et.al., (2018)** To examine the association between the knowledge of breastfeeding and maternal socioeconomic and demographic characteristics, and to determine any impact on child nutritional. A cross-sectional study using both qualitative and quantitative methods was conducted with mothers of infants aged six- to twenty-four months. Data was collected by a semi-structured questionnaire and face-to-face, in-depth interviews with mothers to get an insight into their breastfeeding perceptions and experiences. Educational achievement and occupational class were used as indicators of socio-demographic status. Nutritional status was assessed by anthropometric measurements. The study reveals a significant relationship between exclusive breastfeeding and the mother's education ($P < .001$) and socio-economic status ($P < .001$) has been highlighted. A strong association was found between maternal employment and exclusive breastfeeding ($P < .001$).the findings of the study shed some light on challenges faced by mothers, as well as an association between socio-demographic characteristics and practices for facilitating exclusive breastfeeding to guide the mothers in breastfeeding management[6].

To find out the association between practice of breast feeding among primi mothers with the selected demographic variables

The present study reveals that there is significant association between practice of breast feeding among primi mothers with demographic variables for education of the participant $\chi^2=9.136$ at significant level of $p < 0.05$. The study is supported by a prospective cross-sectional study conducted by **Dr. Haricharan K R, et.al (2017)** To assess the knowledge, attitude and practice of breast feeding among admitted postnatal mothers and to find out their relationship with socio demographic factors. A cross sectional study was carried out in PES Institute of Medical Sciences and research, KUPPAM. The study population included 240 post-natal mothers admitted in the hospital. A face-to-face interview was conducted after delivery during second post-natal day using pretested questionnaire. The study reveals that majority ($n=201$, $\%=87.5$) of mothers belong to age group of 18 to 26 with mean of 23.4 and standard deviation of 3.14. Maximum (87.5%) mothers belonged to Hindu religion. More than half of them were housewives (61%) living in nuclear families and up to 40% of study population were employed. Majority of mothers from study group were primi - para (54.1%). Pre-lacteal feeds were given by 16% and colostrum was discarded by 8% of mothers. About 80% of mothers were knowledgeable and likely to exclusive breast fed their babies. Antenatal counselling was received by 93.3% of mothers and majority of them by doctor 45.91%. Significant association is seen with antenatal counselling ($pvalue < 0.03$) and good breastfeeding practises in post-natal mothers. The study concludes that antenatal counselling promotes good breast-feeding practises hence existing antenatal counselling on breastfeeding needs to be strengthened by informing all pregnant women about the benefits of breastfeeding and motivating them by curtailing their ill beliefs regarding breastfeeding and educating them that breast Feeding is the healthiest and safest way to feed babies[7].

To determine the correlation between knowledge and practice of breast feeding among primi mothers in selected hospitals

The present study reveals that there is a moderate positive correlation between knowledge and practice of breastfeeding regarding breast feeding $r = 0.462$ a significant level of $p < 0.001$



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The present study is supported by a comparative cross sectional study conducted by **Chanda Mog (2021)** on knowledge, attitude and practices regarding Breast Feeding Among Primiparous and Multiparous Mothers in an Urban Slum, West Tripura. The objective of the study was to assess the knowledge, attitude and practices (KAP) regarding breastfeeding among primiparous and multiparous mothers. The study was conducted among 200 mothers (100 primiparous and 100 multipara) in an urban slum and eligible mothers were selected using simple random sample technique. Out of 200 mothers, 118 (59%) had adequate knowledge and 86 (43%) mothers were correctly done breast feeding practices. However, 52% multiparous were found more correctly practicing breastfeeding than primiparous (34%) and it was statistically significant ($P=0.01$). The level of knowledge among multiparous (71%) were found more adequate than primiparous (47%) and significant difference was observed ($P=0.001$). Most of mothers (83%) had positive attitude towards breastfeeding (82% primiparous and 84% multiparous) and mothers did not have any negative attitude towards breastfeeding. The study concludes that the level of Knowledge is still needed to be improved in primipara mothers and however, the correct practice of breastfeeding was also found low in primipara mothers than multipara mothers[8].

CONCLUSION

The present study was conducted to assess the knowledge and practice of breast feeding among primi mothers in a view to develop information booklet in a selected hospital Morigaon District, Assam. A total of 54 primi mothers were participated in the study. Out of 54 respondents it was found that 75.93% primi mothers had moderate knowledge, 24.07% (12) had an adequate knowledge, and 74.07% (40), had a good practice whereas 25.93% (14) had a poor practice regarding breast feeding.

Based on the findings, the researcher concluded that the mother had moderate knowledge and good practice level regarding breast feeding. The knowledge and practice go hand in hand. So, if their knowledge increases their practice level also increased.

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Table 1: frequency and percentage distribution of demographic variables n = 54

Demographic Variables	Frequency (f)	Percentage (%)
Age		
a. Below 20 years	16	29.6
b. 21 – 25 years	24	44.4
c. 26-30 years	14	26
Education of the participant		
a. No formal education	18	33.3
b. Primary	21	38.9
c. Middle school	10	18.5
d. Higher secondary and above	5	9.3
Occupation of the participant		
a. Unemployment	41	75.9
b. Government	5	9.3
c. Private	5	9.3
d. Self-employment	3	5.6
Family income per month		
a. 49,962-74,755	5	9.3
b. 29,973-49,972	8	14.8
c. 10,002-29,972	22	40.7
d. ≤10,001	19	35.2
Place of residence		
a. Urban	21	38.9
b. Rural	33	61.1
Source of information regarding breast feeding		
a. Family member	2	3.7
b. Social media	3	5.6
c. Peer group	15	27.8
d. Health personnel	34	63.0





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Table 2: Association between knowledge of breast feeding among primi mothers with the selected demographic variables n=54

Demographic variables	Knowledge score		Chi square (χ^2)	df	P value	Inference
	Moderate	Adequate				
1.Age	14	2				
a. Below 20 years	17	7	1.668	2	0.434	NS
b. 21-25 years	10	4				
c. 26-30 years						
2.Education of the participant-			8.609	3	0.035	S
a. No formal education	10	8				
b. Primary	20	1				
c. Middle school	7	3				
d. Higher secondary and above	4	1				
3.Occupation of the participant-			4.610	3	0.203	NS
a. Unemployment	31					
b. Government	4	10				
c. Private	5	1				
d. Self-employment	1	0				
		2				
4.Family income per month-			0.123	3	0.989	NS
a. 49,962-74,755	4	1				
b. 29,973-49,972	6	2				
c. 10,002-29,972	17	5				
d. <10,001	14	5				
5.Place of residence			1.801	1	0.180	NS
a. Urban	18	3				
b. Rural	23	10				
6.Source of information regarding breast feeding-	2	0	1.704	3	0.636	NS
a. Family member	2	1				
b. Social media	10	5				
c. Peer group	27	7				
d. Health personnel						

*p<0.05, S – Significant, N.S – Not Significant

Table 3: Association between practice of breast feeding among primi mothers With the selected demographic variables.

Demographic variables	Knowledge score		Chi square (χ^2)	df	P value	Inference
	Poor	Good				
1. Age			2.115	2	0.347	NS
a. Below 20years	6	10				
b. 21-25 years	6	18				
c. 26- 30 years	2	12				
2. Education of the participant-			9.136	3	0.028	S
a. No formal education	2	16				





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b. Primary	10	11				
c. Middle school	2	8				
d. Higher secondary and above	0	5				
3. Occupation of the participant-						
a. Unemployment	11	30	2.369	3	0.499	NS
b. Government	0	5				
c. Private	2	3				
d. Self-employment	1	2				
4. Family income per month-						
a. 49,962-74,755	0	5	2.741	3	0.433	NS
b. 29,973-49,972	3	5				
c. 10,002-29,972	5	17				
d. ≤10,001	6	13				
5. Place of residence						
a. Urban	5	16	0.080	1	0.735	NS
b. rural	9	24				
6. Source of information regarding breast feeding-						
a. Family member	0	2	1.275	3	0.735	NS
b. Social media	1	2				
c. Peer group	3	12				
d. Health personnel	10	24				

*p<0.05, S – Significant, N.S – Not Significant

Table 4: Correlation between knowledge and practice scores of breasts feeding among primi mothers n=54

Category	Mean	SD	r-value	p-value	Inference
Knowledge	9.74	±1.71	0.462	p = 0.0001	S***
Practice	8.26	±1.91			

***p<0.001, S – Significant

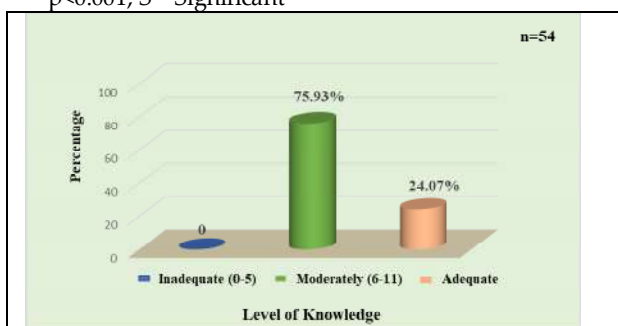


Fig 1: bar diagram showing percentage distribution of knowledge score.

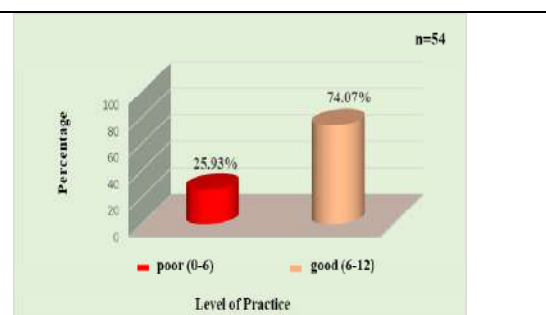


Fig 2: bar diagram showing percentage distribution of practice score.





The Sustainable Fuzzy Eoq Model under Tax Emissions

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ABSTRACT

Emissions of greenhouse gases contributes enormously to global warming, which accelerates temperature rise, disrupts ecosystems, and threatens human health and wildlife. In the industrial sector, increased CO₂ emissions can result in tighter regulations, higher operational costs, and serious reputational damage. Incorporating pollution considerations into inventory management can encourage entities to improve their environmental practices. The main objective of this model is to propose Sustainable EOQ model with tax emissions and its considerations under uncertain environment. All the cost parameters are considered as hexagonal fuzzy numbers. Mathematical formulations are discussed in both Crisp and fuzzy sense. Extension of Lagrangian principle is used to obtain optimal solution. Finally the model illustrated with the Numerical example.

Keywords: Carbon Tax, sustainable, Inventory, Emission.

INTRODUCTION

Erupting CO₂ emissions have been detrimental to the ecological health in the developing world. With the increasing of industries and urbanization, greater quantities of carbon ends up released into earth's atmosphere. A corresponding rise in greenhouse gases intensifies the rate of warming and environmental degradation. Environmental sustainability has grown into a top priority among many companies around all over the globe. In responding to elevated benchmarks from governing bodies, prospects, and stakeholders. Business entities are launching steps intended to minimize their adverse social and environmental consequences, while still being profitable overtime. Based on the vital relevance of global environmental issues and the intricate connection between



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expansion of industries and handling environmental issues, sustainable development and a sense of being sustainable are beginning to gain popularity. The persistent increase in temperatures around the world has driven both consumers and industry to put greater emphasis on emission reductions and safeguarding the environment.[1,2] Inventory remains vital to a company's long-term survival. The majority of supply chain sectors strive to fulfill their consumer demand, enhance client satisfaction, boost receptivity, and optimize productiveness[3]. Alongside with contending on price and assistance, the supply chains are progressively concentrating on ecological sustainability[2]. Inventory costs frequently fall into these categories, ordering costs, which are the costs incurred for ordering things; holding costs, that encompassing the price of maintaining the commodities in facilities. and procurement expenses which related to purchasing specific quantities of goods. These inventory systems have an immense effect on a supply chains emission levels. Stock levels might affect pollutants, especially specific inventory levels either raising or lowering the adverse ecological effects depending on the way the items are carried and operated.[3]. One of the keys for any company's flourishing operations remains in the stock it holds. Conservation issues have emerged as an ongoing emphasize for governments as well as industry. In order to remain fiercely competitive in the business world, companies must focus on environmental complications, like carbon emission, into their strategic initiatives[4,5]. In recent decades, there has been an upsurge of curiosity in the developing inventory structures that adhere to various carbon pricing guidelines. In order to reduce emissions from the industrial processes, regulatory bodies across various advanced economies have enacted a variety of restrictions, But carbon pricing constitutes a notable approach in the industrial aspects.

This tax imposes a fee for the carbon emissions produced by the manufacturers. consequently, with the carbon emission regulations, businesses can try to enhance their management of inventory operations to reduce the carbon emissions amount. In recent times, the emergence of inventory models under various carbon price standards has emerged as a major trend, sparking extensive studies[6]. Arslan and Turkay (2013)[7] extended the traditional EOQ framework through integrating sustainability into carbon pricing systems. Bonney and Jaber (2011)[8] pointed out the necessity of including the effects of environmental factors in inventory models, compared them with conventional strategies. Chen, Benjaafar, and Elomri (2013)[9] displayed that the substantial reduction in emissions can be achieved at minimal expenditure with operational adjustments merely. Battini, Persona, and Sgarbossa (2014)[10] proposed a model that includes environmentally related considerations into a single-product replenishment situation via direct accounting principles. Hovelaque and Bironneau (2015)[11] established a model that investigates sustainability with regard to prices and emission rates, indicating that carbon tax adoption helps both the ecosystem (via lower pollutants) and customers (by more high demand). Dou, Guo, Zhang, and Li (2019)[12] proposed a model for carbon taxation that includes fluctuating rates of taxes over two distinct time frames. Datta (2017) [13] explored a production-inventory model approach that takes into account carbon emissions into implementing taxes concepts. Taleizadeh, Soleymanfar, and Govindan (2018)[14] provided an inventory model which includes sustainability considerations across different shortage policies, highlighting that the approach with partial backordering seemed more comprehensive and effective than the others. Hua, Cheng, and Wang (2011)[15], Kazemi et al. (2018)[16], Wahab, Mamun, and Ongkunaruk (2011)[17] all contributed major advances to this field.

The marketplace is filled with goods and commodities, in which price swings and slides often induce major uncertainties. Fuzzy set theory, with an emphasis on characterizing ambiguity and inaccuracy, has emerged as a vital instrument for utilizing inventory management. Since its inception, the fuzzy set theory's primary task has been marked to address uncertainty-related concerns. Plenty of market factors contributes to this unpredictability, rendering fuzzy set theory essential for fostering inventory studies through the establishment of novel approaches. The adoption of fuzzy models in inventory theory is a major experimental methodology, and many researchers have used fuzzy set theory to come up with far better inventory models[18]. Sharma, Tiwari, Yadavalli and Jaggi(2020) [19] and Mallick and others(2021) [20] proposed an inventory model that accounts for uncertain lead times. Khatua et al,(2021)[21] proposed a production management model in an environment of uncertainty, whereas Govindan (2015)[22] addressed sustainable supply chain management under similar fuzzy situations. Adak and Mahapatra(2020)[23] developed an inventory model that Two-echelon imperfect production supply chain with probabilistic deterioration rework and reliability under fuzziness. Moreover, Pal(2015)[24] made an inventory model





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featuring various fuzzy numbers. and Govindan and others(2020)[25] developed a closed-loop supply network in an imprecise uncertain environment. Ghasemkhani et al (2019)[26] examined the EOQ model for perishable products with fuzzy demand rate. Padiyar and others (2022)[27] developed a joint replenishment method for a multi-item, multi-echelon supply chain model with diminishing products in an inaccurate and inflationary scenario. Karthick and Uthayakumar (2021)[28] developed a sustainable supply chain model that takes into consideration of carbon emissions in the context of fuzzy demand. Recently, Utama and others(2019)[29].examined the problems of determining lot sizes while considering environmental sustainability and capital restrictions into account while purchasing raw materials and paying taxes. The proposed research addresses an inventory model with cost attributes such as ordering, purchasing, and holding costs, along with the corresponding emission considerations and their emission tax .In addition, several cost parameters are represented as hexagonal fuzzy numbers. The solution process is based on an extension of the Lagrangian method, with the Graded Mean Integration representation method used to defuzzify the parameters and achieve optimal results. The values are compared in both crisp and fuzzy forms using a numerical example.

Definitions

An outline of the relevant fuzzy definitions is presented as follows.

Fuzzy Set

A fuzzy set \tilde{C} in a universe of discourse X is defined as the following set of pairs $\tilde{C} = \{(x, \mu_{\tilde{C}}(x)) : x \in X\}$. Here $\mu_{\tilde{C}} : X \rightarrow [0, 1]$ is a mapping called the membership value of $x \in X$ in a fuzzy set \tilde{C} .

Graded Mean Integration Representation Method

If $\tilde{B} = (b_1, b_2, b_3, b_4, b_5, b_6)$ is a Hexagonal fuzzy number then the graded mean representation method of \tilde{B} is a defined as $P(\tilde{B}) = \frac{1}{12}(b_1 + 3b_2 + 2b_3 + 2b_4 + 3b_5 + b_6)$

Arithmetic Operations under Function Principle

The arithmetic operations between Hexagonal fuzzy numbers proposed are given below.

Let us consider $\tilde{A} = (a_1, a_2, a_3, a_4, a_5, a_6)$ and $\tilde{B} = (b_1, b_2, b_3, b_4, b_5, b_6)$ be two Hexagonal fuzzy numbers.

$$\tilde{A} \oplus \tilde{B} = (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4, a_5 + b_5, a_6 + b_6)$$

$$\tilde{A} \ominus \tilde{B} = (a_1 - b_6, a_2 - b_5, a_3 - b_4, a_4 - b_3, a_5 - b_2, a_6 - b_1)$$

$$\tilde{A} \otimes \tilde{B} = (a_1 b_1, a_2 b_2, a_3 b_3, a_4 b_4, a_5 b_5, a_6 b_6)$$

$$\tilde{A} \oslash \tilde{B} = \left(\frac{a_1}{b_6}, \frac{a_2}{b_5}, \frac{a_3}{b_4}, \frac{a_4}{b_3}, \frac{a_5}{b_2}, \frac{a_6}{b_1} \right)$$

Extension of the Lagrangean Method

Taha discussed how to solve the optimum solution of nonlinear programming problem with equality constraints by using Lagrangean Method, and showed how the Lagrangean method may be extended to solve inequality constraints. The general idea of extending the Lagrangean procedure is that if the unconstrained optimum problem does not satisfy all constraints, the constrained optimum must occur at a boundary point of the solution space. Suppose that the problem is given by Minimize $y = f(x)$ sub to $g_i(x) \geq 0, i = 1, 2, 3, \dots, m$ The non-





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negativity constraints $x \geq 0$ if any are included in them constraints. Then the procedure of the Extension of the Lagrangean method involves the following steps.

Step 1: Solve the unconstrained problem $\text{Min } y = f(x)$ If the resulting optimum satisfies all the constraints, stop because all constraints are redundant. Otherwise, set $k = 1$ and go to step 2.

Step 2: Activate any k constraints (i.e., convert them into equality) and optimize $f(x)$ subject to the k active constraints by the Lagrangean method. If the resulting solution is feasible with respect to the remaining constraints and repeat the step. If all sets of active constraints taken k at a time are considered without encountering a feasible solution, go to step 3.

Step 3: If $k = m$, stop; no feasible solution exists. Otherwise, set $k = k + 1$ and go to step 2.

Notations

This research study utilized the following notations that were mostly derived from Maulana's (29) model, to construct the proposed sustainable inventory system.

k_d - Demand

C^p - cost per order

p^u - purchasing cost per unit

g^h - holding cost per unit

e_{oe} - Total emission from ordering

e_{pe} - Total emission from purchasing

e_{he} - Total emission from holding

x_{et} - emission tax cost

\tilde{K}_d -Fuzzy Demand

\tilde{C}^p -Fuzzy cost per order

\tilde{p}^u -Fuzzy purchasing cost per unit

\tilde{g}^h -Fuzzy holding cost per unit

\tilde{e}_{oe} -Total emission from ordering

\tilde{e}_{pe} -Total emission from purchasing

\tilde{e}_{he} -Total emission from holding

\tilde{x}_{et} -emission tax cost

R_{sp} - optimal number of orders

\tilde{R} - Fuzzy optimal number of orders

$TIC(R_{sp})$ - optimal total inventory cost





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$\overline{TIC}(R_{sp})$ - Fuzzy optimal total inventory cost

Assumptions

Assumptions of the SEOQ problems consist of (1) demands, order cost, purchasing cost, holding cost, tax fees, total emissions are considered under uncertain environment (2) components of the assumption are taken as hexagonal fuzzy numbers

Mathematical model

In this model, the study accounted for the costs included with sustainable inventory, considering environmental impact cost, as well as ordering, purchasing, and holding costs. The total inventory cost is formulated as follows:

Mathematical model in crisp sense

$$TIC(R_{sp}) = \frac{(c^p + x_{et} e_{oe})K_d}{R} + K_d(p^u + x_{et} e_{pe}) + \frac{(g^h + x_{et} e_{he})}{2} R \tag{1}$$

Differentiating (1) with respect R , and equate to 0, we get, $R = \sqrt{\frac{2(c^p + x_{et} e_{oe})k_d}{(g + x_{et} e_{he})}}$ (2)

Mathematical model in Fuzzy sense: -

$$\overline{TIC}(R_{sp}) = \left\{ \frac{(\overline{c}^p + \overline{x}_{et} \overline{e}_{oe}) \overline{k}_d}{R} + \overline{k}_d (\overline{p}^u + \overline{x}_{et} \overline{e}_{pe}) + \frac{(\overline{g}^h + \overline{x}_{et} \overline{e}_{he})}{2} R \right\} \tag{3}$$

Now,

$$\begin{aligned} \overline{c}^p &= (c^p_1, c^p_2, c^p_3, c^p_4, c^p_5, c^p_6), \overline{k}_d = (k_{d_1}, k_{d_2}, k_{d_3}, k_{d_4}, k_{d_5}, k_{d_6}) \\ \overline{p}^u &= (p^u_1, p^u_2, p^u_3, p^u_4, p^u_5, p^u_6), \overline{g}^h = (g^h_1, g^h_2, g^h_3, g^h_4, g^h_5, g^h_6) \\ \overline{e}_{oe} &= (e_{oe_1}, e_{oe_2}, e_{oe_3}, e_{oe_4}, e_{oe_5}, e_{oe_6}), \overline{e}_{pe} = (e_{pe_1}, e_{pe_2}, e_{pe_3}, e_{pe_4}, e_{pe_5}, e_{pe_6}) \\ \overline{e}_{he} &= (e_{he_1}, e_{he_2}, e_{he_3}, e_{he_4}, e_{he_5}, e_{he_6}), \overline{x}_{et} = (x_{et_1}, x_{et_2}, x_{et_3}, x_{et_4}, x_{et_5}, x_{et_6}) \end{aligned}$$

are hexagonal fuzzy numbers, the fuzzy total cost is given by,





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$$\overline{TIC}(R_{sp}) = \left[\begin{array}{l} \frac{(c^p_1 + x_{et_1} e_{oe_1})K_{d_1}}{R} + K_{d_1}(p^u_1 + x_{et_1} e_{pe_1}) + \frac{(g^h + x_{et_1} e_{he_1})}{2} R, \\ \frac{(c^p_2 + x_{et_2} e_{oe_2})K_{d_2}}{R} + K_{d_2}(p^u_2 + x_{et_2} e_{pe_2}) + \frac{(g^h + x_{et_2} e_{he_2})}{2} R, \\ \frac{(c^p_3 + x_{et_3} e_{oe_3})K_{d_3}}{R} + K_{d_3}(p^u_3 + x_{et_3} e_{pe_3}) + \frac{(g^h + x_{et_3} e_{he_3})}{2} R, \\ \frac{(c^p_4 + x_{et_4} e_{oe_4})K_{d_4}}{R} + K_{d_4}(p^u_4 + x_{et_4} e_{pe_4}) + \frac{(g^h + x_{et_4} e_{he_4})}{2} R, \\ \frac{(c^p_5 + x_{et_5} e_{oe_5})K_{d_5}}{R} + K_{d_5}(p^u_5 + x_{et_5} e_{pe_5}) + \frac{(g^h + x_{et_5} e_{he_5})}{2} R, \\ \frac{(c^p_6 + x_{et_6} e_{oe_6})K_{d_6}}{R} + K_{d_6}(p^u_6 + x_{et_6} e_{pe_6}) + \frac{(g^h + x_{et_6} e_{he_6})}{2} R \end{array} \right]$$

Now we are going to defuzzify the total cost

$$\overline{TIC}(R_{sp}) = \frac{1}{12} \left[\begin{array}{l} \frac{(c^p_1 + x_{et_1} e_{oe_1})K_{d_1}}{R} + K_{d_1}(p^u_1 + x_{et_1} e_{pe_1}) + \frac{(g^h + x_{et_1} e_{he_1})}{2} R \\ +3 \frac{(c^p_2 + x_{et_2} e_{oe_2})K_{d_2}}{R} + K_{d_2}(p^u_2 + x_{et_2} e_{pe_2}) + \frac{(g^h + x_{et_2} e_{he_2})}{2} R \\ +2 \frac{(c^p_3 + x_{et_3} e_{oe_3})K_{d_3}}{R} + K_{d_3}(p^u_3 + x_{et_3} e_{pe_3}) + \frac{(g^h + x_{et_3} e_{he_3})}{2} R \\ +2 \frac{(c^p_4 + x_{et_4} e_{oe_4})K_{d_4}}{R} + K_{d_4}(p^u_4 + x_{et_4} e_{pe_4}) + \frac{(g^h + x_{et_4} e_{he_4})}{2} R \\ +3 \frac{(c^p_5 + x_{et_5} e_{oe_5})K_{d_5}}{R} + K_{d_5}(p^u_5 + x_{et_5} e_{pe_5}) + \frac{(g^h + x_{et_5} e_{he_5})}{2} R \\ + \frac{(c^p_6 + x_{et_6} e_{oe_6})K_{d_6}}{R} + K_{d_6}(p^u_6 + x_{et_6} e_{pe_6}) + \frac{(g^h + x_{et_6} e_{he_6})}{2} R \end{array} \right] \dots(4)$$

In the following steps, we use extension the lagrangean method to find the solutions of

R_1, R_2, R_3, R_4, R_5 & R_6 to minimize $\overline{TIC}(R_{sp})$

Step 1: -





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$$\frac{1}{12} \left\{ \begin{aligned} & \frac{(c^p_1 + x_{et_1} e_{oe_1})K_{d_1}}{R} + K_{d_1} (p^u_1 + x_{et_1} e_{pe_1}) + \frac{(g^h_1 + x_{et_1} e_{he_1})}{2} R \\ & + 3 \frac{(c^p_2 + x_{et_2} e_{oe_2})K_{d_2}}{R} + K_{d_2} (p^u_2 + x_{et_2} e_{pe_2}) + \frac{(g^h_2 + x_{et_2} e_{he_2})}{2} R \\ & + 2 \frac{(c^p_3 + x_{et_3} e_{oe_3})K_{d_3}}{R} + K_{d_3} (p^u_3 + x_{et_3} e_{pe_3}) + \frac{(g^h_3 + x_{et_3} e_{he_3})}{2} R \\ & + 2 \frac{(c^p_4 + x_{et_4} e_{oe_4})K_{d_4}}{R} + K_{d_4} (p^u_4 + x_{et_4} e_{pe_4}) + \frac{(g^h_4 + x_{et_4} e_{he_4})}{2} R \\ & + 3 \frac{(c^p_5 + x_{et_5} e_{oe_5})K_{d_5}}{R} + K_{d_5} (p^u_5 + x_{et_5} e_{pe_5}) + \frac{(g^h_5 + x_{et_5} e_{he_5})}{2} R \\ & + \frac{(c^p_6 + x_{et_6} e_{oe_6})K_{d_6}}{R} + K_{d_6} (p^u_6 + x_{et_6} e_{pe_6}) + \frac{(g^h_6 + x_{et_6} e_{he_6})}{2} R \end{aligned} \right\}$$

With $0 < R_1 \leq R_2 \leq R_3 \leq R_4 \leq R_5 \leq R_6$; $R_2 - R_1 \geq 0$; $R_3 - R_2 \geq 0$ and $R_4 - R_3 \geq 0$ where $R_1 \geq 0$. Now let all the above partial derivatives equal to zero, and solve R_1, R_2, R_3, R_4, R_5 & R_6 , we get

$$R_1 = \sqrt{\frac{2(c^p_6 + x_{et_6} e_{oe_6})K_{d_6}}{(g^h_1 + x_{et_1} e_{he_1})}}$$

similarly, $R_2 = \sqrt{\frac{2 \times 3(c^p_5 + x_{et_5} e_{oe_5})K_{d_5}}{3(g^h_2 + x_{et_2} e_{he_2})}}$,

$$R_3 = \sqrt{\frac{2 \times 2(c^p_4 + x_{et_4} e_{oe_4})K_{d_4}}{2(g^h_3 + x_{et_3} e_{he_3})}}, R_4 = \sqrt{\frac{2 \times 2(c^p_3 + x_{et_3} e_{oe_3})K_{d_3}}{2(g^h_4 + x_{et_4} e_{he_4})}},$$

$$R_5 = \sqrt{\frac{2 \times 3(c^p_2 + x_{et_2} e_{oe_2})K_{d_2}}{3(g^h_5 + x_{et_5} e_{he_5})}}, R_6 = \sqrt{\frac{2(c^p_1 + x_{et_1} e_{oe_1})K_{d_1}}{(g^h_6 + x_{et_6} e_{he_6})}}$$

Step 2: -

Convert the inequality $R_2 - R_1 \geq 0$ into equality constrain $R_2 - R_1 = 0$ and optimize $TIC(R_{sp})$ subject to $R_2 - R_1 = 0$ by the lagrangean method.

Fix the constraints as $L(R_1, R_2, R_3, R_4, R_5, R_6, \lambda) = \rho [TIC(R_{sp})] - \lambda (R_2 - R_1)$





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$$\frac{1}{12} \left\{ \begin{aligned} & \frac{(c^p_1 + x_{et_1} e_{oe_1})K_{d_1}}{R} + K_{d_1} (p^u_1 + x_{et_1} e_{pe_1}) + \frac{(g^h_1 + x_{et_1} e_{he_1})}{2} R \\ & +3 \frac{(c^p_2 + x_{et_2} e_{oe_2})K_{d_2}}{R} + K_{d_2} (p^u_2 + x_{et_2} e_{pe_2}) + \frac{(g^h_2 + x_{et_2} e_{he_2})}{2} R \\ & +2 \frac{(c^p_3 + x_{et_3} e_{oe_3})K_{d_3}}{R} + K_{d_3} (p^u_3 + x_{et_3} e_{pe_3}) + \frac{(g^h_3 + x_{et_3} e_{he_3})}{2} R \\ & +2 \frac{(c^p_4 + x_{et_4} e_{oe_4})K_{d_4}}{R} + K_{d_4} (p^u_4 + x_{et_4} e_{pe_4}) + \frac{(g^h_4 + x_{et_4} e_{he_4})}{2} R \\ & +3 \frac{(c^p_5 + x_{et_5} e_{oe_5})K_{d_5}}{R} + K_{d_5} (p^u_5 + x_{et_5} e_{pe_5}) + \frac{(g^h_5 + x_{et_5} e_{he_5})}{2} R \\ & + \frac{(c^p_6 + x_{et_6} e_{oe_6})K_{d_6}}{R} + K_{d_6} (p^u_6 + x_{et_6} e_{pe_6}) + \frac{(g^h_6 + x_{et_6} e_{he_6})}{2} R \end{aligned} \right\} - \lambda (R_2 - R_1) \dots\dots\dots (5)$$

Differentiating above equation with respect to $R_1, R_2, R_3, R_4, R_5, R_6, \lambda$ and equate to zero, we get

$$R_1 = R_2 = \sqrt{\frac{2 \left[(c^p_6 + x_{et_6} e_{oe_6})K_{d_6} + 3(c^p_5 + x_{et_5} e_{oe_5})K_{d_5} \right]}{(g^h_1 + x_{et_1} e_{he_1}) + 3(g^h_2 + x_{et_2} e_{he_2})}}$$

$$R_3 = \sqrt{\frac{2 \times 2 (c^p_4 + x_{et_4} e_{oe_4})K_{d_4}}{2(g^h_3 + x_{et_3} e_{he_3})}}, R_4 = \sqrt{\frac{2 \times 2 (c^p_3 + x_{et_3} e_{oe_3})K_{d_3}}{2(g^h_4 + x_{et_4} e_{he_4})}}$$

$$R_5 = \sqrt{\frac{2 \times 3 (c^p_2 + x_{et_2} e_{oe_2})K_{d_2}}{3(g^h_5 + x_{et_5} e_{he_5})}}, R_6 = \sqrt{\frac{2 (c^p_1 + x_{et_1} e_{oe_1})K_{d_1}}{(g^h_6 + x_{et_6} e_{he_6})}}$$

Here, $R_3 \geq R_4, R_4 \geq R_5, R_5 \geq R_6$. It does not satisfy the local optimum.

Step 3: -Now fix the constraints as $L(R_1, R_2, R_3, R_4, R_5, R_6, \lambda_1, \lambda_2) =$

$$\rho \left[TIC(R_{sp}) \right] - \lambda_1 (R_2 - R_1) - \lambda_2 (R_3 - R_2)$$





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$$\frac{1}{12} \left\{ \begin{aligned} & \frac{(c^p_1 + x_{e_{t_1}oe_1})K_{d_1}}{R} + K_{d_1}(p^u_1 + x_{e_{t_1}pe_1}) + \frac{(g^h_1 + x_{e_{t_1}he_1})}{2}R \\ & +3\frac{(c^p_2 + x_{e_{t_2}oe_2})K_{d_2}}{R} + K_{d_2}(p^u_2 + x_{e_{t_2}pe_2}) + \frac{(g^h_2 + x_{e_{t_2}he_2})}{2}R \\ & +2\frac{(c^p_3 + x_{e_{t_3}oe_3})K_{d_3}}{R} + K_{d_3}(p^u_3 + x_{e_{t_3}pe_3}) + \frac{(g^h_3 + x_{e_{t_3}he_3})}{2}R \\ & +2\frac{(c^p_4 + x_{e_{t_4}oe_4})K_{d_4}}{R} + K_{d_4}(p^u_4 + x_{e_{t_4}pe_4}) + \frac{(g^h_4 + x_{e_{t_4}he_4})}{2}R \\ & +3\frac{(c^p_5 + x_{e_{t_5}oe_5})K_{d_5}}{R} + K_{d_5}(p^u_5 + x_{e_{t_5}pe_5}) + \frac{(g^h_5 + x_{e_{t_5}he_5})}{2}R \\ & +\frac{(c^p_6 + x_{e_{t_6}oe_6})K_{d_6}}{R} + K_{d_6}(p^u_6 + x_{e_{t_6}pe_6}) + \frac{(g^h_6 + x_{e_{t_6}he_6})}{2}R \end{aligned} \right\}$$

$-\lambda(R_2 - R_1) - \lambda(R_3 - R_2) \dots\dots(6)$

Now differentiating above equation with respect to $R_1, R_2, R_3, R_4, R_5, R_6, \lambda_1, \lambda_2$ and equate to zero, we get

$$R_1 = R_2 = R_3 = \sqrt{\frac{2[(c^p_6 + x_{e_{t_6}oe_6})K_{d_6} + 3(c^p_5 + x_{e_{t_5}oe_5})K_{d_5} + 2(c^p_4 + x_{e_{t_4}oe_4})K_{d_4}]}{(g^h_1 + x_{e_{t_1}he_1}) + 3(g^h_2 + x_{e_{t_2}he_2}) + 2(g^h_3 + x_{e_{t_3}he_3})}}$$

$$R_4 = \sqrt{\frac{2 \times 2(c^p_3 + x_{e_{t_3}oe_3})K_{d_3}}{2(g^h_4 + x_{e_{t_4}he_4})}}, R_5 = \sqrt{\frac{2 \times 3(c^p_2 + x_{e_{t_2}oe_2})K_{d_2}}{3(g^h_5 + x_{e_{t_5}he_5})}},$$

$$R_6 = \sqrt{\frac{2(c^p_1 + x_{e_{t_1}oe_1})K_{d_1}}{(g^h_6 + x_{e_{t_6}he_6})}}$$

Here, $R_4 \geq R_5, R_5 \geq R_6$. It does not satisfy the local optimum.

Step 4: -

Now fix the constraints as $L(R_1, R_2, R_3, R_4, R_5, R_6, \lambda_1, \lambda_2, \lambda_3) =$

$$\rho \left[TIC(R_{sp}) \right] - \lambda_1(R_2 - R_1) - \lambda_2(R_3 - R_2) - \lambda_3(R_4 - R_3)$$





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$$\frac{1}{12} \left\{ \begin{aligned} & \frac{(c^p_1 + x_{et_1} e_{oe_1})K_{d_1}}{R} + K_{d_1} (p^u_1 + x_{et_1} e_{pe_1}) + \frac{(g^h_1 + x_{et_1} e_{he_1})}{2} R \\ & +3 \frac{(c^p_2 + x_{et_2} e_{oe_2})K_{d_2}}{R} + K_{d_2} (p^u_2 + x_{et_2} e_{pe_2}) + \frac{(g^h_2 + x_{et_2} e_{he_2})}{2} R \\ & +2 \frac{(c^p_3 + x_{et_3} e_{oe_3})K_{d_3}}{R} + K_{d_3} (p^u_3 + x_{et_3} e_{pe_3}) + \frac{(g^h_3 + x_{et_3} e_{he_3})}{2} R \\ & +2 \frac{(c^p_4 + x_{et_4} e_{oe_4})K_{d_4}}{R} + K_{d_4} (p^u_4 + x_{et_4} e_{pe_4}) + \frac{(g^h_4 + x_{et_4} e_{he_4})}{2} R \\ & +3 \frac{(c^p_5 + x_{et_5} e_{oe_5})K_{d_5}}{R} + K_{d_5} (p^u_5 + x_{et_5} e_{pe_5}) + \frac{(g^h_5 + x_{et_5} e_{he_5})}{2} R \\ & + \frac{(c^p_6 + x_{et_6} e_{oe_6})K_{d_6}}{R} + K_{d_6} (p^u_6 + x_{et_6} e_{pe_6}) + \frac{(g^h_6 + x_{et_6} e_{he_6})}{2} R \end{aligned} \right\}$$

$$-\lambda_1(R_2 - R_1) - \lambda_2(R_3 - R_2) - \lambda_3(R_4 - R_3) \dots \dots (7)$$

Now differentiating above equation with respect to $R_1, R_2, R_3, R_4, R_5, R_6, \lambda_1, \lambda_2, \lambda_3$ and equate to zero, we get

$$R_1 = R_2 = R_3 = R_4 = \sqrt{\frac{2[(c^p_6 + x_{et_6} e_{oe_6})K_{d_6} + 3(c^p_5 + x_{et_5} e_{oe_5})K_{d_5} + 2(c^p_4 + x_{et_4} e_{oe_4})K_{d_4} + 2(c^p_3 + x_{et_3} e_{oe_3})K_{d_3}]}{(g^h_1 + x_{et_1} e_{he_1}) + 3(g^h_2 + x_{et_2} e_{he_2}) + 2(g^h_3 + x_{et_3} e_{he_3}) + 2(g^h_4 + x_{et_4} e_{he_4})}}$$

$$R_5 = \sqrt{\frac{2 \times 3(c^p_2 + x_{et_2} e_{oe_2})K_{d_2}}{3(g^h_5 + x_{et_5} e_{he_5})}}, R_6 = \sqrt{\frac{2(c^p_1 + x_{et_1} e_{oe_1})K_{d_1}}{(g^h_6 + x_{et_6} e_{he_6})}}$$

Here, $R_5 \geq R_6$. It does not satisfy the local optimum.

Step 5: -

Now fix the constraints as $L(R_1, R_2, R_3, R_4, R_5, R_6, \lambda_1, \lambda_2, \lambda_3, \lambda_4) =$

$$\rho \left[TIC(R_{sp}) \right] - \lambda_1(R_2 - R_1) - \lambda_2(R_3 - R_2) - \lambda_3(R_4 - R_3) - \lambda_4(R_5 - R_4)$$





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$$\frac{1}{12} \left\{ \begin{aligned} & \frac{(c^p_1 + x_{et_1} e_{oe_1})K_{d_1}}{R} + K_{d_1} (p^u_1 + x_{et_1} e_{pe_1}) + \frac{(g^h_1 + x_{et_1} e_{he_1})}{2} R \\ & +3 \frac{(c^p_2 + x_{et_2} e_{oe_2})K_{d_2}}{R} + K_{d_2} (p^u_2 + x_{et_2} e_{pe_2}) + \frac{(g^h_2 + x_{et_2} e_{he_2})}{2} R \\ & +2 \frac{(c^p_3 + x_{et_3} e_{oe_3})K_{d_3}}{R} + K_{d_3} (p^u_3 + x_{et_3} e_{pe_3}) + \frac{(g^h_3 + x_{et_3} e_{he_3})}{2} R \\ & +2 \frac{(c^p_4 + x_{et_4} e_{oe_4})K_{d_4}}{R} + K_{d_4} (p^u_4 + x_{et_4} e_{pe_4}) + \frac{(g^h_4 + x_{et_4} e_{he_4})}{2} R \\ & +3 \frac{(c^p_5 + x_{et_5} e_{oe_5})K_{d_5}}{R} + K_{d_5} (p^u_5 + x_{et_5} e_{pe_5}) + \frac{(g^h_5 + x_{et_5} e_{he_5})}{2} R \\ & + \frac{(c^p_6 + x_{et_6} e_{oe_6})K_{d_6}}{R} + K_{d_6} (p^u_6 + x_{et_6} e_{pe_6}) + \frac{(g^h_6 + x_{et_6} e_{he_6})}{2} R \end{aligned} \right\}$$

$$-\lambda_1(R_2 - R_1) - \lambda_2(R_3 - R_2) - \lambda_3(R_4 - R_3) - \lambda_4(R_5 - R_4) \dots\dots(8)$$

Now differentiating above equation with respect to $R_1, R_2, R_3, R_4, R_5, R_6, \lambda_1, \lambda_2, \lambda_3, \lambda_4$ and equate to zero, we get

$$R_1 = R_2 = R_3 = R_4 = R_5 = \sqrt{\frac{2 \left[(c^p_6 + x_{et_6} e_{oe_6})K_{d_6} + 3(c^p_5 + x_{et_5} e_{oe_5})K_{d_5} + 2(c^p_4 + x_{et_4} e_{oe_4})K_{d_4} + 2(c^p_3 + x_{et_3} e_{oe_3})K_{d_3} + 3(c^p_2 + x_{et_2} e_{oe_2})K_{d_2} \right]}{\left[(g^h_1 + x_{et_1} e_{he_1}) + 3(g^h_2 + x_{et_2} e_{he_2}) + 2(g^h_3 + x_{et_3} e_{he_3}) + 2(g^h_4 + x_{et_4} e_{he_4}) + 3(g^h_5 + x_{et_5} e_{he_5}) \right]}}$$

$$R_6 = \sqrt{\frac{2(c^p_1 + x_{et_1} e_{oe_1})K_{d_1}}{(g^h_6 + x_{et_6} e_{he_6})}}$$

Here, $R_5 \geq R_6$. It does not satisfy the local optimum.

Step 6: -

Now fix the constraints as $L(R_1, R_2, R_3, R_4, R_5, R_6, \lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5) =$





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$$\rho \left[\overline{TIC}(R_{sp}) \right] - \lambda_1(R_2 - R_1) - \lambda_2(R_3 - R_2) - \lambda_3(R_4 - R_3) - \lambda_4(R_5 - R_4) - \lambda_5(R_6 - R_5)$$

$$\frac{1}{12} \left\{ \begin{aligned} & \left(\frac{(c^p_1 + x_{e_{t_1} o_{e_1}}) K_{d_1}}{R} + K_{d_1} (p^u_1 + x_{e_{t_1} p_{e_1}}) + \frac{(g^h_1 + x_{e_{t_1} h_{e_1}})}{2} R \right) \\ & + 3 \left(\frac{(c^p_2 + x_{e_{t_2} o_{e_2}}) K_{d_2}}{R} + K_{d_2} (p^u_2 + x_{e_{t_2} p_{e_2}}) + \frac{(g^h_2 + x_{e_{t_2} h_{e_2}})}{2} R \right) \\ & + 2 \left(\frac{(c^p_3 + x_{e_{t_3} o_{e_3}}) K_{d_3}}{R} + K_{d_3} (p^u_3 + x_{e_{t_3} p_{e_3}}) + \frac{(g^h_3 + x_{e_{t_3} h_{e_3}})}{2} R \right) \\ & + 2 \left(\frac{(c^p_4 + x_{e_{t_4} o_{e_4}}) K_{d_4}}{R} + K_{d_4} (p^u_4 + x_{e_{t_4} p_{e_4}}) + \frac{(g^h_4 + x_{e_{t_4} h_{e_4}})}{2} R \right) \\ & + 3 \left(\frac{(c^p_5 + x_{e_{t_5} o_{e_5}}) K_{d_5}}{R} + K_{d_5} (p^u_5 + x_{e_{t_5} p_{e_5}}) + \frac{(g^h_5 + x_{e_{t_5} h_{e_5}})}{2} R \right) \\ & + \left(\frac{(c^p_6 + x_{e_{t_6} o_{e_6}}) K_{d_6}}{R} + K_{d_6} (p^u_6 + x_{e_{t_6} p_{e_6}}) + \frac{(g^h_6 + x_{e_{t_6} h_{e_6}})}{2} R \right) \end{aligned} \right.$$

$$- \lambda_1(R_2 - R_1) - \lambda_2(R_3 - R_2) - \lambda_3(R_4 - R_3) - \lambda_4(R_5 - R_4) - \lambda_5(R_6 - R_5) \dots \dots (9)$$

Now differentiating above equation with respect to $R_1, R_2, R_3, R_4, R_5, R_6, \lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5$ and equate to zero, we get

$$R_1 = R_2 = R_3 = R_4 = R_5 = R_6 = R^* = \frac{\left[\begin{aligned} & (c^p_6 + x_{e_{t_6} o_{e_6}}) K_{d_6} + 3(c^p_5 + x_{e_{t_5} o_{e_5}}) K_{d_5} \\ & + 2(c^p_4 + x_{e_{t_4} o_{e_4}}) K_{d_4} + 2(c^p_3 + x_{e_{t_3} o_{e_3}}) K_{d_3} \\ & + 3(c^p_2 + x_{e_{t_2} o_{e_2}}) K_{d_2} + 2(c^p_1 + x_{e_{t_1} o_{e_1}}) K_{d_1} \end{aligned} \right]}{\left[\begin{aligned} & (g^h_1 + x_{e_{t_1} h_{e_1}}) + 3(g^h_2 + x_{e_{t_2} h_{e_2}}) \\ & + 2(g^h_3 + x_{e_{t_3} h_{e_3}}) + 2(g^h_4 + x_{e_{t_4} h_{e_4}}) \\ & + 3(g^h_5 + x_{e_{t_5} h_{e_5}}) + (g^h_6 + x_{e_{t_6} h_{e_6}}) \end{aligned} \right]}$$





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$$R^* = \frac{\left[\begin{array}{l} (c_6^p + x_{e_6} e_{oe_6})K_{d_6} + 3(c_5^p + x_{e_5} e_{oe_5})K_{d_5} \\ + 2(c_4^p + x_{e_4} e_{oe_4})K_{d_4} + 2(c_3^p + x_{e_3} e_{oe_3})K_{d_3} \\ + 3(c_2^p + x_{e_2} e_{oe_2})K_{d_2} + 2(c_1^p + x_{e_1} e_{oe_1})K_{d_1} \end{array} \right]}{\left[\begin{array}{l} (g_1^h + x_{e_1} e_{he_1}) + 3(g_2^h + x_{e_2} e_{he_2}) \\ + 2(g_3^h + x_{e_3} e_{he_3}) + 2(g_4^h + x_{e_4} e_{he_4}) \\ + 3(g_5^h + x_{e_5} e_{he_5}) + (g_6^h + x_{e_6} e_{he_6}) \end{array} \right]} \dots\dots\dots(10)$$

Hence the equation (10) is the required equation of fuzzy optimal order quantity and equation (4) is the required fuzzy total cost

Numerical Example

Consider the values in the below data to represent the proposed sustainable fuzzy inventory model.

$c^p = 20$	$p^u = 6$	$K_d = 25$	$g^h = 1$
$e_{oe} = 30$	$e_{pe} = 2.5$	$e_{he} = 0.5$	$x_{et} = 1$

Solution in crisp model

By using the given values in the data, we obtain the optimal order quantity in the crisp sense as $R = 40.82$ and by using the equation (1) in this model, we obtain the Total cost in crisp sense as $TIC(R_{sp}) = 273.73$

Solution in Fuzzy model

By using the given values in the data, we obtain the optimal order quantity in the fuzzy senses as $R = 40.82$ and by using the equation (1) in this model, we obtain the Total cost in crisp sense as $TIC(R_{sp}) = 273.73$

CONCLUSION

The purpose of this research paper is to develop a method for determining lot size that addresses environmental impacts. It includes an inventory model with considering various cost parameters along with their emission rate and respective carbon tax price. This research work can be extended by future researchers and scholars, by considering some strategies and techniques to lower the emission rates. Because, the growing popularity of today’s industry sectors has been severely hindered by environmental challenges. Carbon tax policy charges companies by imposing an extra fee for emitted Co2. This financial stress propels businesses to embrace greener technologies, boost energy conservation, and explore alternate forms of energy with the goal to lower their their tax burdens. Main research motive of this proposed research work is to encourage other researchers to enhance this study to promote into better sustainability implications that impacts society and wellbeing of humankind and environment



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Reinventing Green Marketing for Sustainable and Innovative Practices in a Changing Business Environment; A Case Study of Sunbird and Phool

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ABSTRACT

Sustainability and ecological sensibility have become a new discourse through which companies have marketed their products since the last decade. While companies have been using advertisements and scientific green washing techniques to position themselves effectively in the market, there has always been a gap between their environmental strategies and corporate strategies. This gap stemmed from an ignorance of the component of 'people' out of the 7 P's of marketing. At a time when the world is shifting to a future that is sustainable, it is important that the business world also follows suit, bridging this gap. Hence, there is a need to reinvent existing green marketing strategies holistically that integrate both sustainability and profitability. This research paper aims to analyse the case studies of two startups - Sunbird and Phool - to look at their green marketing strategies, which focus largely on humanities. Both these startups came into their respective industries, identifying relevant ecological concerns and working towards a sustainable world while delivering high-quality products and making profits. Using the Theory of Disruptive Innovation, the paper explores how, as new entrants, they have reinvented green marketing strategies that have given them a place of their own in the dynamic business environment. Their usage of the trope of storytelling and pitching in the nuances of the circular economy that they created have been pivotal in their successful business journey. The paper looks at how they differentiate themselves from the rest of the industry by identifying the similarities in their strategies. Furthermore, the paper will also enquire about the potential of these marketing strategies to become the pioneer in initiating a larger ecologically sensitive marketing paradigm in India.

Keywords: Green marketing, Storytelling, Circular economy, Sustainability, Woman empowerment, Social impact.



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INTRODUCTION

In a dynamic business environment that envisages an integrative approach wherein sustainability and profitability go hand in hand, startups must consistently re-imagine their marketing strategies. As companies and consumers are becoming more aware of the environmental concerns that are looming large, there is an acknowledgement of the need to pursue sustainable business practices (White 20). Green Marketing has become a popular alternative with a focus on the environmental imperative and self-interests of businesses, marketers and customers. The Indian economy is going through a transition, which is very well seen in the country's GDP and PPI. The International Monetary Fund (IMF) has predicted that India's GDP will grow by 6.8 per cent in FY 2022/23 and by 6.1 per cent in FY 2023/24. India's increasing production and exports have raised expectations about its potential to reshape the global order and emerge as one of the largest global markets for a wide range of products and services. These economic reforms and liberalisation have made many robust changes in the country's business environment, with more and more private players coming into the market and providing significant contributions to the world market. This has also resulted in a modification of the existing business environment. Changes in India's business environment can be traced back to economic liberalisation, digital transformation, and the present-day shift towards renewable energy, eco-friendly products, and biodegradable products. Out of these changes, the government ban on identified single-use plastic items has drastically impacted the country's business environment. India is the fifth-highest generator of plastic waste in the world. The government indeed recognised the adverse effect of littered single-use plastic items on terrestrial and aquatic ecosystems, and they took the measure to ban many of the single-use plastic items to tackle the environmental challenges faced by the country and the world.

In 2019, the Indian government banned six single-use plastic items: plastic bags, cups, plates, small bottles, straws, and certain types of sachets. The ban was initially introduced in 129 cities and towns and was later extended to the entire country. This has resulted in more companies coming up with environment-friendly alternatives and a change in the overall business environment, which was limited to plastic products. Consumer behaviour towards the ban on single-use plastic in India has been positive, as there is a growing trend towards more sustainable practices. One of the primary reasons for this change in consumer behaviour is the increasing awareness of the negative impact of single-use plastic on the environment. This information is disseminated mainly by the government through television, social media, and other platforms; consumers are becoming more conscious of the need to reduce their consumption of single-use plastic products through Green Marketing. Green marketing is an encompassing marketing approach that synergistically amalgamates various strategic activities with the overarching goal of expanding market share, while concurrently offering environmentally conscious products and services. Apart from traditional marketing, green marketing can help with several issues like wastage of water, recycling of wastes and air pollution due to toxic substances. Due to the enlightenment of all these issues nowadays, even producers and consumers prefer more eco-friendly products for the betterment of the ecosystem and their health.

The success of green marketing is that consumers view these green products as the most appealing and safe. So, green marketing demands the application of sound marketing principles to be a trustworthy product. Consumer value positioning, calibrating consumer knowledge, and credibility of product claims are effective marketing and producing tools for green products in India's present scenario of green marketing. Even though India has made a lot of attempts in the area of green marketing, it is still in its infancy. Green Marketing and Traditional Marketing have varying philosophies. The parties involved in exchange for traditional marketing are the firm and the customer, whereas green marketing includes adding to the environment. In terms of objectives, Green Marketing has to minimise ecological impact. A certain amount of social responsibility is involved in green marketing and designing beyond legal frameworks to sustain the environment. The concept of Circular Economy (CE) originated in the 1970s with the goal of decreasing the use of resources in industrial production. However, it has the potential to be applied to any kind of resource. By utilizing the natural cycle model, CE aims to make human activities more sustainable, proposing a shift from the current "extraction-production-disposal" model of the linear economy (LE) that is widely used in the industrial sector. This concept has gained acceptance to address the issue of sustainability in public





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policies in governments such as those of the European Union (House of Commons, 2014) and has been implemented as a national development strategy in China (Arruda, et al, 2021). In terms of marketing strategies, two models remain at the forefront. The first marketing mix comprises the 7Ps (product, price, promotion, place, process, physical evidence, and people) put forward by Gordon in 2012. Then there are also the 4Ps developed by Booms and Bitner (1981), a framework developed from McCarthy's 1960 framework. The 4Ps framework includes product, price, place and promotion (Eniezan et al. 2016). Notwithstanding the high dissatisfaction with the 4Ps, their framework is considered the most significant for introductory and consumer marketing (Eniezan et al. 2016). There are certain disadvantages to the 4Ps where it lacks people, participants and participants and processes. There is also a lack of connection/integration between the variables (Goi, 2009).

The paper will look at two startups - Sunbird and Phool - that have adopted environmentally sensible practices to develop and market their products. Phool is an Indian startup founded in 2017 that makes incense sticks and vermicompost out of used flowers from the temple. They have made an impactful intervention from an ecological perspective by identifying the menace caused by dumping pesticide-laden flowers into water bodies. The dumped flowers are collected and then made into charcoal-free incense sticks that are organic and biodegradable. Their 'flower cycling' technology is managed by a group of women called 'flower cyclers' who have now assured a healthy livelihood. Today, they employ 73 women who have worked towards recycling more than 11,060 tons of flowers since its inception. Phool has both B2C and B2B businesses, wherein the former happens through their e-commerce website. They continue to focus on R&D to develop nuanced methods to produce biodegradable products like bio leather, organic vermicompost and soaps. Sunbird Straws is a multi-layered biodegradable straw made of fallen, dry coconut leaves. This first-of-its-kind endeavour has also developed machinery to cut and process the straws from dry coconut leaves collected and cleaned off its midrib. These machines are now capable of making a straw in 1.5 seconds. These straws have the edge over paper straws that get soggy and are not eco-friendly since they are made from cut trees and processed using chemicals. These biodegradable straws, in that sense, decompose themselves like a natural dry coconut leaf. While focussing on the ecological and social impact they impart, Sunbird has also not derailed from its commercial journey either. They aim to produce 15 lakh straws monthly within the first half of 2023. The startup employs 86 women from rural areas who take care of most of the processes, including sourcing, sorting, processing and packaging. These companies have gone beyond the narrow categories of eco-friendly consumption to go beyond product development and include ecologically sensitive marketing strategies and production processes. Phool and Sunbird have played a seminal role in synthesising a circular economy model addressing a previously overlooked ecological concern through a holistic approach founded upon environmental sustainability.

Through an extensive study of the functionality of the two startups, the paper aims to curate the green marketing strategies of Sunbird and Phool in a dynamic industry 4.0 scenario wherein ecological sensibility, commercial interests and immersive customer experience should go hand in hand. The case study of Sunbird and Phool provides an excellent example of how green marketing can be reinvented for sustainable and innovative management practices in a country like India, where the transition to sustainable living practices remains a luxury. Both these companies have successfully differentiated themselves in their respective markets by emphasising their commitment to sustainability and innovative management practices. By contextualising green marketing within the discourse of sustainable marketing practices through the functionalities of Sunbird and Phool, the paper will look at how they have re-imagined their marketing strategies in a sustainable manner and how other companies can adopt and adapt to similar practices. The 7Ps of marketing have the disadvantage of being too long, making it more complicated. Also, the 4Ps have limited but better reliability as they can adapt quickly to various problems. 7P has an essential inclusion that the 4Ps neglect – People. People have become a significant USP in the emergence of Sunbird and Phool. The storytelling involving the people and the product features has reinvented the process of Green Marketing. The case study will help locate People's roles in sustainable and innovative green marketing and how improving the circular economy can benefit our society in the long run. The paper will explore these companies' key strategies to reinvent green marketing for a sustainable future. If the reinvention of the methods is innovative, how are Sunbird and Phool contributing to the Circular Economy? This paper will also investigate the approaches employed by Phool and Sunbird towards green marketing and the way in which they contribute to the circular economy. Disruptive



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Innovation Theory curated by Clayton Christensen in the 1990s discusses the ways in which new entrants in a market can disrupt its ecosystem by starting from the bottom and then moving upwards (Christensen 1997). In this context of the research, disruptive innovations are considered as a process and not as a product or service. Disruptive innovations are focussed on the ways in which firms create, deliver and appropriate value. The theory explains the patterns of entrants in a dynamic business environment. It looks at the ways in which new entrants in the market focus on creating new market segments by operating in value networks that are contextual to customer needs. Thus an innovation that is an improvement along the value system that has been historically valued by the customers will be more sustainable and successful. However, disruptive innovations do not cater to the large customer base of the established companies which creates an asymmetry between the new entrants and incumbents. It is in this space that startups like Sunbird and Phool pitch themselves. In that way, Christensen argues that new entrants will improve their performance over time superseding the incumbents and slowly capturing the whole market segment (Christensen and Rosenbloom 1995). The paper, by employing the nuances of disruptive innovation theory, attempts to understand how Phool and Sunbird contribute to the circular economy through their strategies of green marketing. The processes adapted by the new entrants are never perceived as an immediate threat to established companies but have the potential to climb up the market and create disruptive changes. By looking at how Sunbird and Phool reinvent the existing marketing strategies and slowly create an impact amongst the customers, the disruptive innovation theory will throw light on the ways in which they can tackle their competitors and bring their marketing practices to the forefront in their respective domains.

Reinventing Marketing Strategies - A Move Away from Negative Marketing

Negative marketing has been one of the key marketing strategies used by companies all over the world to promote their brand. Negative marketing, also known as attack advertising or competitive advertising, involves directly criticising or attacking a product or company to make your own brand appear superior. This strategy has been employed by both start-ups as well as established companies through various means such as advertising, social media campaigns and public relations. There are two subtypes of negative marketing, attack and contrast. The attack focuses on the negative sides of the competitor's offerings, and the contrast focuses on the positive sides of your offering and establishes the gap. This way is believed to be a more subtle way which would still highlight what the competitors lack. Wilkie defines comparison advertising as a form of advertising that compares two or more brands that sell the same kind of product or service class. They make comparisons based on their service attributes and product lines (Wilkie 1975). The strategy of using Negative Marketing or comparative advertising to promote a product is something that has been around for a very long time. Especially now, with the influence of social media and other advertising platforms, negative marketing has become one of the easiest ways to push a product by comparing it with the cons of a competitor's product. While this can be effective in generating attention and creating a buzz, it can also backfire and damage a brand's reputation. Typically, larger brands find it easier to use negative marketing against their competition since they are already well-known. Therefore, the potential reward outweighs the risk of highlighting value propositions. It is argued that the comparison ad has the ability to ease the consumer's role of evaluating and deciding on one brand against the other based on their performance; better places products or "superior" products are usually benefitted from the early use of comparison advertising which inadvertently stimulate improvements in the product by its competitors which are however considered "below par" (Wilkie 1975). Phool and Sunbird are two companies that have employed different ways of marketing and never used negative marketing to push their products. Without comparing their product to that of the competitors or by attacking advertising, Phool and Sunbird have successfully made their entry into sustainable and innovative market practices. They have employed different green marketing techniques, which focus largely on the idea behind the startup, goal and vision. One of the most unique and effective green marketing strategies used by these companies is the storytelling method.

Nascent Approaches in Green Marketing Strategies - A Reinvention Through Storytelling

Green marketing has become an integral part of business strategies ever since the growing concerns on environmental sustainability and climate change at a global level. It was aimed at fostering cleaner production and encouraging sustainable consumption (Nidumolu et al 2009). Over the past three decades, companies have been



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trying to develop products that are environmentally sustainable and market them by creating awareness about the ecological impact that their products can have. Considering the long history of green marketing as a whole and sustainable product in particular, Sunbird and Phool are new entrants in the market. However, their green marketing strategies were not only unique but were also offering a sustainable future which qualifies these strategies to be capable of being the future leaders in the industry. While green marketing is generally regarded as the “integration of environmental sustainability into marketing”, it can be seen that these two startups have gone beyond these definitions to reinvent existing practices (Dandelico and Vocellelli 2017). Green marketing strategies for a long time have been an unending struggle to find a balance between environmental sensitivity and corporate strategies. Companies have been trying to integrate environmental strategies that are capable of bringing in competitive merit and profitability into their midst (Leonidou et al 2013). Due to the increasing tendency to greenwash the companies’ marketing strategies, they have developed superficial marketing strategies. The traditional green marketing strategies have followed the 4Ps format. They are product, price, promotion and place. However, in the 7Ps of marketing, People are an important element. Hence, there has always been a gap between environmental strategies and corporate strategies. It is in this gap that companies like Sunbird and Phool make a difference through their integrated and reinvented marketing strategies. Both companies have identified an untapped segment of the existing market so as to pitch in their unique selling proposition. Unlike the regular companies in their industry, they have reinvented the existing green marketing strategies to fit within their Unique Selling Propositions. Sunbird and Phool’s marketing strategy thrives on two things - storytelling and circular economy. They have been able to create a unique story with respect to their product, production and consumption. They have weaved their startup story into their marketing strategy to pitch themselves to their customers. The storytelling aims to incorporate the notion of People from the 7Ps to establish a new model that reinvents the current aspects of green marketing.

Sunbird is the world’s first premium multi-layered drinking straw, which is made from dried coconuts. Unlike the paper, steel and bamboo counterparts, Sunbird Straws has antifungal and hydrophobic outer and inner walls, which makes them unique and truly eco-friendly. Their straws can be used in cold beverages for 3 hours and have a shelf life of 9 months. With a production rate of 2 lakh straws every month, they have already replaced 0.5 million plastic straws already and prevented 52 kg of Carbon Monoxide from entering the environment. Sunbird aims to produce 15 lakh straws per month in 2023. They have nine production units in total that span the rural areas of Kerala, Karnataka, and Tamilnadu, which are run predominantly by native women. These women are mostly from abusive households (from the interview with the founder). Currently, they have employed 86 women at various stages of their production. The entire process, from the collection of raw materials to cleaning and processing, is sustainably done with machines made by the company itself. They have been able to retain all their employees so far. Earning a revenue of Rs 18 crore, Sunbird aims to further increase its production to 10 lakh straws per day and employ 1000 women. Table 1 shows the social impact made by Sunbird so far. The company used the social impact that they have created over the years to pitch in their product along with their quality.

Despite being new entrants in their respective markets they were able to make an impact by using the storytelling trope to put forth the larger social impact that they are making by employing women, using eco-friendly raw materials and sustaining families in the rural areas. As far as Phool is concerned, they were able to identify a severe menace that was unrecognised for a long time. Floral offerings are a part of the majority of Indian culture. The environmental concerns invited by the dumping of pesticide-laden flowers into water bodies have been going unnoticed until the founders identified them during their visit to various pilgrimage sites. Since its inception, Phool has been able to make a significant impact both environmentally and commercially. They have become the world's first profitable and lean solutions company that has solved the problem of temple waste. Through their flower cycling technology, they make handcrafted charcoal-free incense sticks and organic and biodegradable packing materials. With the profit made, they have also educated 19 students so far. Their entire business production employs 73 women on a full-time basis which has improved the livelihood of 73 families by at least sixfold. Their relentless efforts have resulted in the upcycling of over 2500 metric tons of floral waste that has removed over 275 kilograms of pesticide residue from river Ganga. Table 2 summarises the social impact made by Phool so far. They were creating a circular economy wherein they not only created a livelihood for a group of people but also pioneered a culture that





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encourages the reusing of materials that were hitherto discarded as waste. They take care to minimise unnecessary wastage and cut the use of plastic. While marketing their products, Phool and Sunbird put forth the social impact that they have been creating by empowering women in their businesses through their storytelling strategies. They carefully tailor their stories to align with the value systems that have been appreciated by society at large. In the light of the Theory of Innovative Disruption, these sustainable innovations are the strategies that not only got these companies their entry into the market but also will help them climb upward slowly. By pitching in their innocuousness with the livelihood that they provide to their employees, their startup story in itself becomes their marketing strategy. Through the interviews conducted with the CEOs of respective startups, it was inferred that a lot of people buy their products because of the social impact that their story creates. At the same time, they also are careful about maintaining high quality for their products which will ensure profitability that goes beyond the social impact that they are creating through storytelling. With this, the notion of People from the 7Ps gets incorporated with the 4Ps to form a new model that reinvents green marketing strategies. The disruptive innovation theory looks for strategies that are capable of changing existing competitive patterns. The patterns that Sunbird and Phool put forth are capable of this disruption in the future is what their success story is trying to say. In a dynamic business environment that is focusing relentlessly on sustainability, the marketing strategies of Phool and Sunbird have the capability of being mainstream strategies.

Green Marketing and Circular Economy aiding a country's development

The reinvention of Green Marketing strategies has increased the consumption of more sustainable and eco-friendly products. Circular Economy (CE), as a fundamental idea and practice looks forward to minimising waste and increasing the utility and lifespan of materials along side preserving its value (Lehmann et al. 2022). The Circular Economy is also a pivotal tool in overcoming the menace of climate change and pollution. Jansson (2016) posits that by mending and remanufacturing, companies can bring down the necessity of new primary raw materials, improve the lifespan of products and reduce the emission of CO₂ and other toxins. This is where Sunbird and Phool prioritise the sustainability and prosperous ecological life that stems from the circular economy. On the other hand, the reinvention of Green Marketing strategies not only dwells on the impact it can have on decreasing waste and CO₂ emissions and sustaining a prosperous ecological life. It has focused on the impact and lives of People contributing to the sustenance of our environment. One of the most neglected aspects of the 4Ps is the People, an element in the 7Ps framework. Phool and Sunbird have utilised the importance of the people. They aim to uplift people from backward societies through their ecologically beneficial products. Their business enables the companies to support the workforce, people from backward areas of society, to move forward economically and in other spheres of life.

One particular way they have contributed to the betterment of the people is through an added emphasis on storytelling. The marketing aims to convince the consumers to deviate from the usual products, focusing on ecologically safe products and their impact on the workforce behind nature-friendly products. The workforce for these products are women from lower class and abusive households and the companies try to uplift them to succeed in all spheres of life. The impact brought towards the lives of these women, their families and sustainable products indicates a heartwarming but impactful story that can benefit the country in their ecological and economic concerns. When people become the USP, and the product can solve many ecological problems, consumers have shown no reluctance to shift towards a more sustainable option. The social media engagements and the story behind Sunbird and Phool shed light on their social impact on our country. Employing women and uplifting them from being dependent on their husbands is a small start to uplifting a backward community or region. The support the backward class people can benefit from if consumers shift from harmful products to sustainable products that benefit our environment. The model of creating a story worth telling around a product that creates jobs, reduces pollution, and is recyclable could shift the direction of any country. The United Nations Industrial Development Organisation, for over 50 years, has worked towards enabling countries for a circular economy for sustainable development. According to the Ellen MacArthur Foundation, by 2025, circular business models could generate about \$1 trillion per year of materials cost savings. This can certainly be an effective model for a country like India. The invaluable impact of Circular Economy and Green Marketing is that in the possible ways to move towards a resource-efficient production model and create environmentally friendly products, it also provided a pathway to improve the social





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conditions of life. Effective utilisation of Circular Economy and Green Marketing can lead to shared prosperity. Poverty eradication and creating employment opportunities for lower-class women can drive the development of a country like India immensely. Phool and Sunbird have shown that it is working. They employ women from backward communities, providing them with regular incomes to advance in all spheres of life. It is not just safeguarding our environment but also looking after its inhabitants. The storytelling involved with Sunbird and Phool and their impact on social life has paved the way for the reinvention of green marketing to move towards a sustainable and effective circular economy.

CONCLUSION

Sunbird and Phool have demonstrated an innovative and holistic approach to business that balances both sustainability and profitability. By creating environmentally-friendly products, they have addressed the urgent need for sustainable solutions and pioneered a circular economy model to combat the ecological and economic problems that persist. Their marketing strategy is also noteworthy, as they prioritise the workforce and emphasise the social impact of their products. Providing their workforce that comprises women from lower classes, and abusive homes with substantial income primarily helps the people get ahead in life. The companies also handle the education of their kids and other needs. Using the impact brought in through the business of ecologically friendly products becomes the reinvention of green marketing strategy to move towards a more sustainable business environment. Sunbird and Phool have not used 'negative marketing' to market their product. Altogether, they have completely reinvented the green marketing strategies, where neglect towards People from the 4Ps has been utilised in the new model. This approach benefits the environment and supports women from disadvantaged backgrounds, which is a commendable social initiative. In addition, their circular economy model has the potential to generate significant revenue for India and promote sustainable development. Ellen MacArthur Foundation states that a productive Circular Economy can generate trillions of revenue for a country. Sunbird and Phool serve as inspiring examples of how businesses can thrive while prioritising sustainability and social responsibility. Their success is not only a model to protect the environment but more beneficial to produce a sustainable model of the economy for our country.

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Quantification of Arm Strength Performance in Response to High Intensity Interval Training and Moderate Intensity Continuous Training among College Women Athletes

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ABSTRACT

Increased muscular strength has been shown to improve performance in general sport skills like jumping, sprinting, and direction-changing, according to a large body of studies. According to more studies, athletes who are stronger perform better when performing tasks unique to their sport. One's performance in a variety of sports, including basketball, volleyball, and swimming, will increase if your biceps are strong. Arm curls are a great exercise to add to one's fitness regimen if one wants to succeed in sports that need upper body strength and power. The purpose of the study was to quantify arm strength performance in response to high-intensity interval training and moderate-intensity continuous training among college women athletes. Forty-five (N=45) women athletes were selected as subjects. They were divided randomly into three groups of fifteen each i.e., (n=15) Group-I underwent high-intensity interval training (HIIT), Group-II underwent moderate-intensity continuous training (MICT) and Group-III acted as control group (CG). The training period was limited to three days per week for twelve weeks. Arm strength was selected as dependent variable and it was measured through push-ups test. All the subjects were tested prior to and immediately after the experimental period on the selected dependent variable. The data obtained from the experimental groups and control group before and after the experimental period were statistically analyzed with Analysis of covariance (ANCOVA). Whenever the 'F' ratio for adjusted posttest means was found to be significant, the Scheffe's Post hoc test was applied to determine the paired mean differences. The level of confidence was fixed at 0.05 level for all the cases. High-intensity interval training (HIIT) was found to be better than the Moderate-intensity continuous training (MICT) and Control group in developing arm strength.

Keywords: Interval Training, Continuous Training, High-Intensity, Moderate-Intensity, Arm Strength, Athletes





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INTRODUCTION

A form of exercise known as interval training involves a sequence of high-intensity sessions separated by rest or relaxation periods. While the recovery intervals entail lower-intensity activity, the high-intensity periods are often at or near anaerobic exercise[1]. Interval training is simply a type of exercise where a rest period or recovery time is allowed in between two repetitions of a low to high intensity activity. In general, interval training entails working out at progressively higher intensities (from low to high), separated by rest intervals[2]. The average race pace is multiplied by four seconds to estimate the exercise intensity. This is the maximum amount of exercise time that can be manipulated, and the rest period has an adequate impact on the strength of the training stimulus[3]. Six intensity zones, including Super maximum (>100), maximum (90-100), Heavy (80-90), Medium (70-80), Low (50-70), and Very Low (50), can be used to categorize the intensity[4]. Short bursts of intensive activity are interspersed with less strenuous recovery intervals in a form of exercise known as high-intensity interval training (HIIT). It is also sometimes referred to as sprint interval training (SIT), high-intensity intermittent exercise (HIIE), or Tabata (after the professor who investigated this form of training in Olympic speed skaters)[5]. To improve motor fitness components, moderate-intensity continuous training techniques and high-intensity interval training are frequently advised. Continuous or long, slow distance training entails steady-paced, extended exercise at either low or high aerobic intensity, typically between 60 and 80% of one's maximum oxygen uptake (VO₂max). Continuous exercise has been shown to enhance plasma volume, capillary density, oxidative enzyme activity, and VO₂max in untrained people[6].

METHODS

Participants

Forty-five (N=45) women athletes studying various arts and science colleges in Coimbatore District, Tamilnadu, India were selected randomly as subjects. The age, body mass and standing body height of the subjects was ranged between 17 to 20 years, 50 to 55 kilograms, 1.46 to 1.62 meters respectively.

Study Design

The subjects were divided randomly into three groups of fifteen each i.e., (n=15) Group-I trained high-intensity interval training (HIIT), Group-II trained moderate-intensity continuous training (MICT) and Group-III acted as Control (CG). The subjects performed their training interventions for three days per week for twelve weeks. The control group did not entertain any specific type of activity except the college curriculum.

Data Collection

Arm strength was selected as dependent variables and it was measured through push-ups test[®]. The data on Arm strength was collected from the participants before and after the training interventions.

Statistics

The data collected from the experimental groups and control group on prior and after training interventions on arm strength was statistically examined by analysis of covariance (ANCOVA) was used to determine differences, if any among the adjusted post test means on selected criterion variables separately. Whenever they obtained f-ratio value was significant the Scheffe's test was applied as post hoc test to determine the paired mean differences, if any. In all the cases 0.05 level of significance was fixed.

RESULTS

Arm Strength

The analysis of covariance on arm strength of the pre, post, and adjusted test scores of HIIT group, MICT group and Control group have been analyzed and presented in table – 1. The table-1 shows that the pre-test means values of arm strength for HIIT, MICT and CG are 4.63, 5.00 and 5.27 respectively. The obtained 'F' ratio of 0.45 for the pretest

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mean is lesser than the table value of 3.22 for degrees of freedom 2 and 42 required for significance at 0.05 level of confidence on arm strength. The posttest means values of arm strength for HIIT, MICT and CG are 7.47, 6.67 and 5.33 respectively. The obtained 'F' ratio of 9.84 for the posttest mean is greater than the table value of 3.22 for degrees of freedom 2 and 42 required for significance at 0.05 level of confidence on arm strength. The adjusted posttest means values of arm strength for HIIT, MICT and CG are 7.60, 6.74 and 5.13 respectively. The obtained 'F' ratio of 34.01 for the adjusted posttest mean is greater than the table value of 3.23 for degrees of freedom 2 and 41 required for significance at 0.05 level of confidence on arm strength. The analysis of the study indicated that there was a significant difference between the adjusted post-test means of HIIT, MICT and CG on arm strength..The pre and posttest mean value of experimental groups on arm strength his graphically represented in the Figure -1. Pair wise comparisons of Scheffe's Post Hoc test results are presented in table – 2. Table-2 shows that the mean difference values of HIIT and MICT, HIIT and CG, MICT and CG are 0.87, 2.48 and 1.61 respectively, which are greater than the confidence interval value of 0.77 on Arm Strength at 0.05 level of confidence. The results of the study showed that there was a significant difference between HIIT and MICT, HIIT and CG, MICT and CG. The above data also reveal that HIIT is better than MICT and CG.The adjusted posttest mean value of experimental groups on arm strength is graphically represented in the Figure -2.

DISCUSSION ON FINDINGS

The results of the study indicate that all the experimental groups namely High-Intensity Interval Training and Moderate-Intensity Continuous Training have significantly improved in arm strength. Further the results of the study showed control group showed there is no significant improvement. It is also found that the improvement effected arm strength by HIIT is greater when compared to the effects of MICT and CG.

CONCLUSIONS

Significant differences were found between High-Intensity Interval training, Moderate-Intensity Continuous Training and Control group in arm strength. The Experimental groups namely, High-Intensity Interval training (HIIT) group, and Moderate-Intensity Continuous Training (MICT) group had significantly improved in arm strength. The High-Intensity Interval training (HIIT) group was found to be better than the Moderate-Intensity Continuous Training (MICT) group and Control group in the performance of arm strength.

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Table-1: Showing the analysis of co-variance on the parameter of Arm Strength(Measures in Counts)

Test	HIIT	MICT	CG	Source of Variance	Sum of Squares	df	Mean Squares	F-ratio
Pre-Test Mean	4.63	5.00	5.27	Between groups	0.93	2	0.47	0.45
				Within groups	43.87	42	1.04	
Post-Test Mean	7.47	6.67	5.33	Between groups	34.84	2	17.42	9.84*
				Within groups	74.40	42	1.77	
Adjusted Post-Test Mean	7.60	6.74	5.13	Between sets	46.40	2	23.2	34.01*
				Within Sets	27.96	41	0.68	

HIIT- High-Intensity Interval Training, MICT- Moderate-Intensity Continuous Training, CG- Control group,df- degree of freedom, * Significant at 0.05 level of confidence, Table value for df (2, 42) at 0.05 level = 3.22, Table value for df(2, 41) at 0.05 level = 3.23

Table-2: Scheffe’s test for the Difference between Paired Means on Arm Strength (Measures in Counts)

HIIT	MICT	CG	Mean Difference	Confident Interval Value
7.60	6.74	---	0.87*	0.77
7.60	---	5.13	2.48*	
---	6.74	5.13	1.61*	

*Significant at 0.05 level of confidence.



Fig-1: Bar diagram on ordered pre and posttest means of Arm Strength



Fig-2: Bar diagram on ordered adjusted posttest means of Arm Strength





Nano-Carrier based Intranasal Drug Delivery System

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ABSTRACT

The article explores the intranasal route of drug administration as an emerging and promising method, garnering increasing attention in recent years. Focusing on the advantages of direct nose-to-brain targeting, the paper discusses how intranasal delivery offers improved bioavailability, circumvents invasive techniques, and provides a non-invasive approach to crossing the blood-brain barrier (BBB). Addressing the challenges in treating major brain diseases, including Alzheimer's, schizophrenia, and Parkinson's, the article emphasizes the potential of intranasal administration to enhance central nervous system (CNS) bioavailability. The anatomical aspects of the nasal cavity, comprising vestibular, respiratory, and olfactory regions, are detailed to underscore the unique features supporting effective drug transport. Mechanisms of nose-to-brain transport, including the paracellular and transcellular pathways, are explored, emphasizing the suitability of lipophilic medications for effective absorption. The article delves into the realm of nasal nanotechnology, highlighting nanocarriers such as solid lipid nanoparticles, liposomes, polymeric nanoparticles, and nanoemulsions. These carriers are discussed in the context of increasing residence time, mucoadhesive strength, and viscosity of nasal mucosa, as well as their interaction with olfactory nerve fibers and BBB endothelial cells. Novel nanotechnologies, especially lipid-based nanoparticles like solid lipid nanoparticles (SLN) and nanostructured lipid carriers (NLC), are presented as effective solutions to overcome limitations in drug delivery systems. Recent advances in drug delivery, including antibodies-mediated delivery, gene vectors, and stem cell therapies, are also discussed. The article concludes by highlighting the benefits of intranasal administration, including enhanced therapeutic efficacy, improved targeting capabilities, and increased bioavailability. Despite the potential drawbacks, the growing investment by pharmaceutical companies underscores the significance of intranasal medication in the global pharmaceutical market. The study suggests that SLN and NLC

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represent more efficient options for intranasal drug administration, presenting a promising future for the treatment of neurodegenerative diseases.

Keywords: Intranasal administration, non - invasive, nanoparticles, Blood - brain - barrier, neurodegenerative disorders.

INTRODUCTION

Drug administration by parenteral and oral routes has been investigated in recent years. Here, we discuss the intranasal route of administration, which has drawn increasing attention lately. New technology and nasal formulations are introduced to reduce negative effects [1]. It is the simplest method—nose to brain targeting, which has a better bioavailability and is direct brain targeting without intrusive techniques or blood stream clearance. As a result, we may conclude that intranasal administration is non-invasive and BBB-passing. It might perhaps make medications more CNS bioavailable. Tight connections between its endothelial cells when it passes the BBB can stop chemicals from leaking from the blood into the brain [2]. Major brain diseases like Alzheimer's, schizophrenia, and Parkinson's disease lack a specific medication that can be taken in severe situations, which can result in death. Not even brain illnesses have been fully elucidated yet [3]. The brain illnesses have the symptoms such as oxidative stress, mental toxicity, blood pressure etc. The primary cause of the oxidative stress in this case is the overproduction of reactive oxygen species. Thus, it is revealed that antioxidant therapy is not permitted in the management of neurodegenerative diseases (NDD) [4]. Studies conducted in vitro as well as in vivo have surrounded it. When compared to other carrier particles, lipid nanoparticles can enhance nose-to-brain drug transport even more quickly due to their biodegradability [5], bioacceptability, and quick brain absorption. The intranasal delivery of medications may be increased by the nanosized carrier particles in comparison to the drug solutions [6].

ANATOMY

Anatomically speaking, the nasal cavity is located between the roof of the mouth and the base of the skull. The structure is made up of two identical cavities that are separated by the septum, which is located along the mid-sagittal plane [7]. The mucosa-lined cavities have a combined area of approximately 150 centimeters. It is further separated into three regions:

1. Vestibular area
2. The breathing area
3. Area of smell

VESTIBULAR REGION

Also referred to as the nasal vestibule, this is the initial region. It is 0.6 centimeters in area. The vestibular area is shielded by stratified squamous and keratinized epithelial cells with sebaceous glands. The nasal hairs in this area, sometimes referred to as vibrissae^s, filter the particles that are inhaled.

RESPIRATORY REGION

Conchae is another name for it. It is vascular and covers the greatest area, around 130 cm². It is the cavity, which is separated into inferior, middle, and superior cavities. The lateral wall is where the cavities are projected or originated from [9]. The pseudostratified epithelium in this respiratory area is dominated by four cell types. They are non-ciliated columnar cells, basal cells, ciliated columnar cells, and goblet cells [10]. Sebaceous and mucous glands are also included. The goblet cells, which are primarily in charge of mucus secretion, are part of the respiratory region's major physiology. Basal cells are found on the basal membrane. By retaining moisture and promoting active transport, these cells aid in preventing mucosal drying. It is made up of cilia, which are in charge of increasing the respiratory surface area. A complex mixture, comprising 95% water, 2% mucin, 1% salts, and other proteins such as albumin, lysozymes, immunoglobulins, 1% lactoferrin, and <1% lipids, make up the nasal secretion [11].





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OLFACTORY REGION

The olfactory region, which includes the neuroepithelium, is the only area of the central nervous system that is in direct contact with the outside world. Through the BBB, the medication is absorbed and makes its way to the brain. Similar to the respiratory region, it is made up of several olfactory cells and pseudostratified epithelium[12].

MECHANISM OF NOSE - TO - BRAIN TRANSPORT

Molecules travel from the nasal cavity to the cerebral cortex via two channels as part of the transport process. The chemicals spread throughout the brain after being given to the pons and cerebrum[13].

- Paracellular pathway
- Transcellular pathway

PARACELLULAR PATHWAY

The paracellular route, which passes through the nasal epithelium's tight connections, carries hydrophilic medications. This mechanism is the first one[14]. For several medications, a molecular weight larger than 1000Da was associated with low bioavailability. For effective absorption, lipophilic medications such as fentanyl, progesterone, pentazocine, and propranolol are utilized[15].

TRANSCELLULAR PATHWAY

That is the other mechanism. Nasal administration uses the transcellular pathway, which involves active transport by peptides and glycoproteins, to transfer nasal epithelium. The lipophilic medications will be transported here. Moreover, for the medications to enter the brain, they must pass through the blood-brain barrier [16].

NANOPARTICULATE CNS DELIVERY THROUGH NASAL ROUTE

Much effort has been paid to nasal nanotechnology over the last few decades. Solid lipid nanoparticles, liposomes, polymeric nanoparticles, and nanoemulsions are examples of nanocarriers used in nasal nanotechnology that are effective in delivering drug delivery systems[17]. When opposed to intranasal delivery, new nanotechnology often offers a higher flow rate, meaning that it can more easily cross the blood-brain barrier and get to the brain. The poorly distributed medication will be introduced into the nanocarrier-based particles and come into touch with three distinct regions[18].

- 1) The residence time, mucoadhesive strength, and viscosity of the nasal mucosa all increase.
- 2) Olfactory nerve fibers that facilitate drug transfer from the nasal cavity to the central nervous system.
- 3) The medication will pass the blood-brain barrier by interacting with endothelial cells in the BBB and demonstrating its therapeutic benefits for brain disorders. The tiny size of the nanocarrier molecules allows them to quickly traverse the blood-brain barrier and enter brain-to-nose pathways. Different targeting ligands found in nanocarrier-based systems bind to particular receptors to exhibit therapeutic benefits as well as an improvement in brain specificity and affinity[19]. Nasal nanotechnology is significantly more effective and safe to use[20].

NOVEL NANOTECHNOLOGY

NANOPARTICLES

Nowadays, researchers are investigating the use of nanoparticulate systems for intranasal administration as a more effective drug or vaccine delivery method[21]. Nanoparticles are within the nanosize range in terms of size. Similar to microparticles, nanoparticles also enhance medication solubility and metabolism. When compared to conventional drug delivery, instead of nanoparticulate drug delivery, the bioavailability of the former is superior due to its reduced size range of particles. Polymers and lipids, or occasionally both, are the building blocks of nanoparticles because they form controlled nanostructures and enable prolonged and regulated drug release[23].

LIPID BASED NANOPARTICLES:

Solid matrix structures known as lipid nanoparticles were created as an alternative to polymeric, nanogel, and nanoemulsion nanoparticles[24]. Similar to nanoparticles, the size range of SLN is likewise extremely small, ranging



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from 1 to 1000 nm[25]. Since the solid lipid nanoparticles' surface is made up of physiological lipids and surfactants, they are usually regarded as safe for the body to consume. Triglycerides, monoglycerides, diglycerides, fatty acids, and waxes are the commonly used lipids[26]. These advanced delivery systems are solid lipid nanoparticles. These can lessen or circumvent the polymeric nanoparticulate systems' limitations. There are two generations involved here. SLN is part of the first generation, whereas nanostructured lipid carriers (NLC)[27] are part of the second generation. NLC are recognized for their ability to get over first generation's drawbacks. The lipid matrix, which can prevent proteolytic breakdown of proteins after delivery and enhance protein stability[28].

RECENT ADVANCES**ANTIBODIES MEDIATED DRUG DELIVERY**

The last 10 years have seen a surge in interest in antibodies, but their big size limits their capacity to traverse the blood-brain barrier and their permeability, which further limits their potential for antibody-mediated therapy of neurodegenerative diseases[29].

GENE VECTORS TUMORS

Gene vectors are administered into the intranasal cavity to limit blocking of the blood-brain barrier, allowing the vectors to easily cross the barrier and exhibit therapeutic effects in the brain[30].

STEM CELL THERAPIES

Because stem cells can regenerate dead cells in injured places, they are the most forbidden choice for treating a wide range of disorders. These days, pump sprays are used to deliver nasal treatments in various markets. They are liable and the easiest for the patients to use[31].

CONCLUSION

The subjects we covered in this article are linked to brain targeting via intranasal injection of nanoparticles, which is utilized to treat neurodegenerative illnesses. The outlines of the nasal cavity will become clear to readers, and many of the approaches that are described here are still fundamental. Intranasal administration has many non-invasive benefits. The medication is delivered straight into the central nervous system (CNS) by avoiding the blood-brain barrier. The enhanced therapeutic efficacy, improved targeting capabilities, and increased bioavailability of these nanoparticulate carriers are promising and cutting edge characteristics. Furthermore, pharmaceutical businesses are investing a significant sum of money due to the increased demand for nasal medication items in the worldwide pharmaceutical market. It was also mentioned, although, that the intranasal route has a number of drawbacks that need to be addressed in order to create an effective nasal medication. In the end, the SLN and NLC for the intranasal route of medication administration seem to be a more effective choice for illness treatment delivery.

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Environment Management through the Lens of Ancient, Medieval and Modern Indian Literature

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ABSTRACT

The article explores the intricate field of environmental management through the lens of ancient and medieval Indian teachings. In ancient India, revered texts like the Vedas and Upanishads valued nature as *Prakriti*, stressing its sacredness and the imperative to protect it. These foundational writings laid the groundwork for a comprehensive approach to caring for the environment, seamlessly blending spiritual reverence with practical sustainability principles. As we move into the medieval period, Mughal rulers implemented strict regulations to safeguard the environment, recognising its crucial role in societal well-being. Their governance prioritised ecological balance, imposing penalties for environmental violations. By comparing ancient philosophical ideas with historical governance practices, this study illuminates the lasting relevance of traditional wisdom in today's environmental discourse. It offers insights that transcend time and culture, fostering a renewed understanding of living in harmony with the natural world. Modern Indian writers, philosophers and academicians have also expressed their concerns about the Environment and its relationship with human life. The paper also focuses on the values of the Environment and its balance with Human lives and the various schemes that are laid down for Environmental Management.

Keywords: Environment, India, Management, Literature.





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INTRODUCTION

The environment is the natural world surrounding human life and is closely associated with the atmosphere, hydrosphere, lithosphere and biosphere. In general, Environment includes plants, animals, rocks and the entire landscape. But it is to be matter of concern that the environment is in wilderness and it is also necessary to the management of the environment then environmental management is more concerned with the management of human activities as by *M.E Colby* in his book *Environmental Management in Development: The Evolution of paradigms* (1991) says "All human activities take place in the context of certain types of relationships between society and the biophysical world the rest of nature" (p 193) [1]. Environment management encompasses a systematic approach to overseeing the delicate balance of our surroundings, focusing on mitigating pollution, averting environmental catastrophes, and curbing degradation. At its core, it entails the strategic deployment of policies, practices, and technologies to safeguard ecosystems, biodiversity, and human health. This multifaceted discipline not only addresses immediate threats like pollution but also anticipates and prevents potential disasters through proactive measures. Moreover, it promotes sustainable resource utilization, fostering resilience against environmental shocks while minimizing ecological footprint. By integrating scientific research, regulatory frameworks, and community engagement, environment management strives to harmonize human activities with the natural environment, ensuring its longevity for future generations. Embracing a holistic perspective, it underscores the interconnectedness of environmental, social, and economic systems, advocating for responsible stewardship and fostering a culture of environmental consciousness and accountability. However, environmental management is the understanding of the environment and how humans relate to this environment [2]. More broadly, environmental management includes identifying the environmental problem, finding its solution, no exploitation, utilization of natural resources, control environmental pollution, reduce the impacts of extreme natural disaster, make optimum utilization of natural resources and making them eco-friendly as nature is both destroyer and creator Jim Clyburn writes, "Environment protection doesn't happen in a vacuum. You can't separate the impact on the environment from the impact on our families and communities (Jim)" [3].

RESEARCH METHODOLOGY

This paper aims to discover the environmental management during ancient and medieval period and its impact in modern time. This research shows light on the importance of environment, environment problems since ancient time and actions taken in the ancient, medieval and modern period by the people. The paper discusses how to provide the insight of managing the environment and awareness in society. The research approach is descriptive in nature. The paper is based on secondary data which has been taken from various books, articles and journals.

Ancient Literature and Environment Management

In ancient times, the environment was intricately intertwined with the essence of life itself, embodying principles of wisdom, tranquility, and abundance. Former President of India, Dr. Abdul Kalam, in his seminal work "Ignited Minds: Unleashing The Power Within India" (2010), posited that ancient India epitomized a society rich in knowledge and adorned with a flourishing civilization (p. 21)[4]. This profound insight underscores the profound reverence ancient societies held for their natural surroundings, recognizing it as a source of sustenance, enlightenment, and prosperity. Rekindling this legacy of knowledge empowerment entails integrating such wisdom into modern education systems, thereby illuminating paths towards peace, prosperity, and contentment for India and beyond. By embracing the harmonious coexistence with nature advocated by our forebears, we pave the way for a future where the synergy between knowledge, education, and environmental consciousness becomes the cornerstone of societal progress and well-being. **पुष्पितःफलवन्तश्चतर्त्यन्तीहमानवान्। वृक्षदंपुत्रवत्वृक्षास्तारयन्तिपरत्रच॥** (*Mahabharat, Anusasan Parv, Adhyaya, 58, Shloka 30*)





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Humans who plant trees that produce fruits and flowers for welfare of human kind are assisted by those trees in after life, as son assists his father and saves him from the pains of Other World.

The ancient Indian philosophy exemplifies a profound admiration for the environment, reflecting a holistic worldview that intertwines ecological harmony with spiritual enlightenment. Across revered texts like the Vedas, Puranas, Upanishads, Mahabharata, Bhagavad-Gita, and Ramayana, the ethos of environmental stewardship resonates, encapsulated within the concept of Prakriti [5]. These scriptures extol the virtues of knowledge, peace, bliss, and prosperity, all of which are inherently linked to a harmonious relationship with nature. In ancient culture, the environment, encompassing forests, trees, and animals, was revered, with teachings emphasizing the interconnectedness of all life forms and elements of nature – be it space, air, fire, water, or earth. Central to this ethos was the cultivation of a deep-seated love and respect for nature, instilling in individuals a profound sense of responsibility to coexist in symbiotic equilibrium with the natural world. This holistic perspective not only nurtured ecological balance but also fostered spiritual growth and societal well-being, serving as a timeless beacon of wisdom for humanity [6]. In the Bhagavad Gita' Lord Krishna says,

पत्रपुष्पफलं तोययो मे भक्त्या प्रयच्छति।

तदहं भक्त्युपहृतमश्नामि प्रयतात्मनः॥

(Bhagwat Gita, Chapter 3, Shloka 13)

If one offers me with love and devotion a leaf, a flower, fruit or water, I will accept it.

We get a clearer statement that a tree supports an ecosystem and by its cutting/burning the system is destroyed.

महान्वृक्षो जायते वर्धते च तत्रैव भूतानि समाश्रयन्ति।

यदा वृक्षश्छिद्यते दह्यते च तदा श्रया अनिकेता भवन्ति॥

(Mahabharat, Shanti Parv, Adhyaya 69, Sloka 73)

The ancient Hindu text of The Manusmriti stands as a testament to the profound reverence for life and the environment inherent in Hindu philosophy. Within its verses, a resounding condemnation is voiced against cruelty towards animals, illustrating the deep-seated belief in the interconnectedness of all living beings. The Manusmriti's admonishment against the killing of cattle, symbolizing the sanctity of all life forms, is particularly poignant. It declares that the perpetrator of such an act is fated to endure a karmic reckoning, destined to suffer as many deaths as there are hairs on the skin of the slain cattle. This striking injunction serves not only as a moral imperative but also as a poignant reminder of the intrinsic value of every living creature. It underscores the ancient wisdom that reverberates through Hindu teachings, emphasizing compassion, empathy, and the imperative of living in harmony with the natural world. In its essence, this profound insight transcends time and culture, offering timeless guidance on the path towards ethical conduct and ecological stewardship (Bithin1075) [7]. The Vedas also asserted that the plants and trees are the cosmic being and valuable for descendents. Besides Vedas, Upanishads, Puranan, Sutras and other sacred texts of Hinduism Mahabharata, Bhagavad-Gita and Ramayana contain a number of references of the love and worship of the Environment [8]. Many plants and flowers were used for worship, the **Lotus** (*Nelumbo nucifera*) was considered a sacred flower and the Indian **Basil** (*Ocimum basilicum*), **Peepal Tree** (*Ficus religiosa*) and **Banyan Tree** (*Ficus benghalensis*) is still worshipped. Similarly, the Earth, water, air, animals and forest were given significant values in the ancient period so as to protect the environment [9].

Medieval Literature and Environment Management

During the medieval period, the perception of nature underwent a significant shift, with people viewing it not just as a backdrop for life but as a source of delight and aesthetic appreciation. This era witnessed the construction of monuments, parks, and gardens along riverbanks, meticulously designed to capture and amplify the beauty of the natural world [10]. Babur's "Babernama" (1589) and Jahangir's "Tuzuk-I Jahangiri" (1609) offer vivid descriptions of Indian geography, embellished with intricate details of flora, fauna, ponds, and the scenic splendor of nature during that epoch. Historical records and architectural marvels bear testimony to the profound affinity medieval rulers held for nature. Whether it was the Rajput Maharajas or conquerors from the West, leisure time was often spent amidst the serene embrace of nature, their architectural endeavors serving as tributes to the preservation and celebration of



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natural beauty. Through their unique architectural styles, these rulers sought to harmonize human creations with the organic elegance of the environment, manifesting a collective desire to cultivate and cherish the inherent splendor of nature. This symbiotic relationship between humanity and the natural world during the medieval period reflects a nuanced appreciation for the interconnectedness of life and underscores the enduring allure of nature's charm across diverse cultural landscapes. **Source:** District Srinagar, Govt of J & K Available at <https://srinagar.nic.in/gallery/shalimar/> Once the Jahangir visited Kashmir, he said about the India's beautiful nature[11] which Stephen P Blake in his book *shahjahanabad: the sovereign city in mughalIndia 1639-1739* and writes,

Agar firdaus bar ru-ye zaminast

Hamin ast-o haminast-o haminast

If there is a paradise on the face of the earth.

It is this, it is this, it is this.

Amir Khusro— Amir Khusrau, The Writings Of Amir Khusrau:700 years after the prophet: a 13th-14th century legend of Indian-sub-continent.[12]

During the medieval period, environmental management strategies were characterized by a multifaceted approach aimed at enhancing the natural landscape while also preserving its integrity for future generations. Forestation efforts were actively promoted, recognizing the vital role of forests in maintaining ecological balance and providing essential resources. Additionally, considerable emphasis was placed on the protection and construction of water reservoirs to ensure reliable water supply for agricultural, domestic, and industrial purposes. Emperors and rulers played a pivotal role in shaping the environmental ethos of the time, commissioning artists to depict breathtaking landscapes and architects to design ornate gardens and monuments that celebrated the splendor of nature. Iconic historical gardens like the Mughal Garden in New Delhi, Shalimar Bagh in Srinagar, Jammu & Kashmir, and Verinag Garden in Anantnag, Jammu & Kashmir, stand as enduring testaments to this reverence for nature's beauty [13]. However, alongside these efforts to promote and enjoy nature, strict punitive measures were also implemented to deter environmental degradation. Harsh penalties were imposed on those found guilty of harming the environment, reflecting a recognition of the intrinsic value of ecological balance and the need for its preservation. As a result of these concerted efforts, the condition of the environment during the medieval period was relatively well-maintained, with a balance struck between human activities and the preservation of natural ecosystems. This holistic approach to environmental management serves as a historical precedent for sustainable practices that continue to resonate in contemporary environmental discourse.

Modern methods of Environment Management

In modern times, the study of the environment falls under the purview of Earth Science, encompassing the natural world comprising earth, trees, water, animals, birds, and landscapes. Renowned poet Rabindranath Tagore's collection of poetry, "Gitanjali" (1913), eloquently weaves themes of earth, trees, water, animals, and birds, setting an example of the profound relationship between nature and humanity. Tagore's teachings advocate for a life lived in harmony with nature, yet, regrettably, contemporary environmental phenomena are endangered due to the neglect of environmental values, leading society towards widespread environmental degradation [14]. India's environmental challenges stem from rapid economic development and population growth, evident in the degradation of environmental quality and beauty, underscoring the growing detachment of humans from nature and the declining sentiment towards environmental conservation. Despite these challenges, various governmental and private initiatives have been undertaken to improve environmental values. Since 1972, numerous private agencies have worked towards environmental protection, addressing issues such as pollution, climate change, and solid waste management [15]. India's legislative framework reflects a commitment to environmental preservation, with significant acts like the Water Prevention and Control Act (1974), Environment Protection Act (1986), and Air Pollution Control Act (1981), along with international agreements like the Convention on Biological Diversity (1992) [16]. Additionally, the government of India, under Prime Minister Narendra Modi's leadership, has launched several ambitious schemes aimed at environmental conservation. Initiatives such as the Swachh Bharat Abhiyan (2014), Bal Swachhta Abhiyan (2014), and the Namami Ganga Yojna (2014) exemplify concerted efforts to tackle environmental challenges comprehensively [17]. These endeavors underscore India's commitment to nurturing its natural



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surroundings and safeguarding its environmental heritage for future generations. By integrating traditional wisdom with modern environmental governance and fostering a culture of environmental stewardship, India strives to overcome the pressing challenges posed by environmental degradation, ensuring a sustainable and prosperous future for all.

DISCUSSION

The environment serves as a guiding force, offering sustenance, balance, and inspiration to humanity. Yet, in the relentless pursuit of economic gain, mankind has often disregarded this guidance, exploiting the environment for short-term gains and inflicting irreparable damage upon delicate ecosystems. Modern environmental management systems have emerged as a response to mitigate these impacts, aiming to regulate and improve the interaction between human activities and the environment. These systems prioritize the preservation of human health and well-being while striving to minimize negative environmental consequences. However, amidst the clamour for modern solutions, traditional knowledge systems have often been overlooked and undervalued. Across diverse cultures, traditional knowledge encompasses a vast repository of wisdom spanning various domains, including environmental stewardship. Unfortunately, with the passage of time, this invaluable knowledge has been eroded, as younger generations increasingly prioritize formal education over learning from their elders. As elderly members of communities pass away, much of this practical wisdom vanishes with them, leaving behind only fragmented remnants or sporadic records. Nevertheless, there exists immense potential in preserving and revitalizing traditional knowledge for environmental management. This ancient wisdom, passed down through generations, holds invaluable insights into sustainable resource management, ecosystem conservation, and harmonious coexistence with nature. By safeguarding and revitalizing traditional knowledge, we can bridge the gap between past wisdom and modern scientific understanding, forging a holistic approach to environmental management that integrates the best of both worlds. Efforts to document and preserve traditional knowledge systems are crucial in this endeavor. Through collaborative partnerships between indigenous communities, researchers, and policymakers, traditional ecological knowledge can be systematically recorded, documented, and revitalized. By doing so, we not only honor the rich cultural heritage of indigenous peoples but also unlock a treasure trove of practical wisdom that can inform contemporary environmental management practices. Integrating traditional knowledge into modern environmental management frameworks offers a pathway towards more holistic and sustainable approaches. By leveraging indigenous wisdom, communities can develop locally appropriate solutions to pressing environmental challenges, rooted in centuries-old traditions of ecological stewardship and resilience. In essence, saving and revitalizing traditional knowledge for environmental conservation is not merely an exercise in preserving the past; it is an investment in our collective future. By harnessing the wisdom of our ancestors and integrating it with modern scientific understanding, we can forge a path towards sustainable development that honours both the needs of present generations and the integrity of the natural world.

CONCLUSION

The environment encompasses various elements that bring joy and tranquillity to human beings, from its vibrant colours to its diverse landscapes. Individuals need to prioritize environmental conservation and strive to maintain ecological balance. Today, improving environmental values necessitates fostering a harmonious relationship with nature and adhering to government schemes aimed at environmental protection. Despite the efforts of the Ministry of Environment and other organizations to safeguard the Earth, human greed often takes precedence, leading to the degradation of the environment and disrupting the planet's peace. Mahatma Gandhi's timeless words, "Earth provides enough to satisfy every man's needs, but not every man's greed," resonate profoundly in the modern era [18]. These words underscore the importance of restraining human desires and embracing sustainable practices to ensure the well-being of both present and future generations. In this context, it becomes imperative to revive ancient knowledge systems that espouse principles of environmental harmony and apply them to contemporary environmental management practices. By integrating traditional wisdom with modern scientific understanding,





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society can develop innovative solutions to address pressing environmental challenges. This includes leveraging indigenous knowledge of ecosystem management, sustainable agriculture, and natural resource conservation. Furthermore, educational initiatives can play a crucial role in raising awareness about the importance of environmental stewardship and encouraging individuals to adopt eco-friendly lifestyles. In essence, caring for the environment is not only a moral imperative but also a practical necessity for ensuring the continued prosperity of humanity and the planet. By heeding the lessons of the past and embracing a holistic approach to environmental management, mankind can forge a path towards a more sustainable and harmonious coexistence with nature.

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Figure 1: Terraces of Shalimar Bagh Srinagar, Srinagar, Jammu & Kashmir, India





Fixed Point Theorems in Orthogonal Space for Contractive Self Mapping

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ABSTRACT

We establish a shared common fixed point in an Orthogonal Hausdorff topological space with a τ -distance in this paper. Next, for two or more classes of contractive self-mappings in complete orthogonal bounded metric space, we derive two common fixed-point theorems. Moreover, we illustrate some examples to support our result.

Keywords: Fixed point, contractive self-mapping, orthogonal complete metric space, Hausdorff topological space, weakly compatible mapping.

INTRODUCTION

Nemytzki [13] initiate the Study of contractive or shrinking self-mappings on a metric space (X, d) (i.e., $d(Tx, Ty) < d(x, y), \forall x \neq y \in X$). Moreover, as M. Edelstein mentioned in [7], the prerequisite for achieving a fixed contractive self-mapping point, is to either presume that the space is compact or that a point $x \in X$ exists for a sequence $\{T^n x\}$ such that it contains a convergent subsequence. B. E. Rhoades shown in [1], that each weakly contractive mapping on a complete metric space (X, d) has a unique fixed point, or we can also say that every self mapping $T : X \rightarrow X$ satisfy the condition $d(Tx, Ty) \leq d(x, y) - \varphi(d(x, y))$, for all $x, y \in X$, where $\varphi : [0, +\infty) \rightarrow [0, +\infty)$ is a non-decreasing continuous function such that $\varphi(0) = 0$. Since then, a number of findings about this class of mappings have been published in the literature [2, 5, 12, 14]. M. Aamri and D. E. Moutawakil developed the idea of τ -distances in [6] for general topological spaces (X, τ) , and it was then extended to numerous known spaces in the literature. They also demonstrated the well-known Banach's fixed point for this general setting. In this work, we extend several ideas





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introduced by D. E. Moutawakil and Y. Touaila [15] to orthogonal sets and prove a few fixed point theorems. Our findings complement and generalize the established findings. Additionally, we provide some examples that support our findings.

PRELIMINARIES

This section aims to help you remember some terminology and findings that are necessary for the article. Let (X, τ) be a topological space and $p : X \times X \rightarrow [0, \infty)$ be a function. For any $\varepsilon > 0$ and $\forall x \in X$, let $B_p(x, \varepsilon) = \{y \in X : p(x, y) < \varepsilon\}$

Definition 2.1. ([6]) The function p is said to be τ -distance if for each $x \in X$ and any neighborhood V of x , there exists $\varepsilon > 0$ such that $B_p(x, \varepsilon) \subset V$.

Definition 2.2. A sequence $\{S_n\}$ is said to be Cauchy sequence if $\forall \varepsilon > 0, \exists n \in \mathbb{N}$ such that $|S_{m+p} - S_n| < \varepsilon, \forall m > n, p > 0$

Definition 2.3. ([15]) A sequence in a Hausdorff topological space X is a p -Cauchy if it satisfies the usual metric condition with respect to p .

Definition 2.4. A space is said to be complete if every Cauchy sequence in it is a convergent sequence.

Definition 2.5. ([6]) Let (X, \perp) be an orthogonal set (O-set). Any two elements $x, y \in X$ are said to be orthogonally related if $x \perp y$.

Definition 2.6. ([6]) Let (X, τ) be a topological space with a τ -distance p .

1. X is S -complete if for every p -Cauchy sequence (x_n) , there exists x in X with $\lim p(x, x_n) = 0$.
2. X is p -Cauchy complete if for every p -Cauchy sequence (x_n) , there exists x in X with $\lim x_n = x$ with respect to τ .
3. X is said to be p -bounded if $\sup\{p(x, y) | x, y \in X\} < \infty$.

Lemma 2.7. Let (X, \perp, τ) be an Orthogonal Hausdorff topological space with a τ -distance p , then

1. $p(x, y) = 0$ implies $x = y, \forall x, y \in X, x \perp y$ or $y \perp x$
2. Let (x_n) be an orthogonal sequence in X such that $\lim_{n \rightarrow \infty} p(x, x_n) = 0$ and $\lim_{n \rightarrow \infty} p(y, x_n) = 0$, then $x = y, \forall x, y \in X, x \perp y$ or $y \perp x$

Definition 2.8. ([15]) Two self-mappings f and g of a set X are said to be weakly compatible if they commute at their coincidence points; i.e., if $fu = gu$ for some $u \in X$, then

$$(fg)u = (gf)u.$$

Definition 2.9. ([2]) θ is the class of all functions $\theta: [0, +\infty) \rightarrow [0, +\infty)$ satisfying:

- i) θ is a monotone increasing function,
- ii) $\theta(t) = 0$ if and only if $t = 0$.

Definition 2.10. ([2]) Ψ is the class of all functions $\psi: [0, +\infty) \rightarrow [0, +\infty)$ satisfying:





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- i) ψ is nondecreasing,
- ii) $\lim_{n \rightarrow \infty} \psi^n(t) = 0$, for all $t \in [0, \infty)$.

Definition 2.11. ([2]) Φ is the class of all functions $\varphi: [1, +\infty) \rightarrow [0, +\infty)$ satisfying:

- i) $\varphi(t) = 0$ if and only if $t = 1$,
- ii) $\inf t > 1 \varphi(t) > 0$.

Main result

Theorem

Let (X, \perp, τ) be a p - bounded Orthogonal Hausdroff topological space with a τ – distance p . Let q, r, s and t be two \perp – continuous and \perp – preserving weakly compatible self mapping of X . Satisfying the following condition

For every $x, y \in X, q(x) \perp q(y)$ or $q(y) \perp q(x)$,
 $r(x) \perp r(y)$ or $(y) \perp r(x)$,
 $s(x) \perp s(y)$ or $s(y) \perp s(x)$
 and $t(x) \perp t(y)$ or $t(y) \perp t(x)$

1. $t(X) \subseteq s(X) \subseteq r(X) \subseteq q(X)$
2. $P(rx, ry) \leq \psi(p(qx, qy))$, where $\psi \in \Psi$
3. $P(sx, sy) \leq \psi(p(rx, ry))$, where $\psi \in \Psi$
4. $P(tx, ty) \leq \psi(p(sx, sy))$, where $\psi \in \Psi$

If the range of q, r, s and t are S- Complete subspace of X then q, r, s and t have a unique common fixed point.

Proof: Since X is an orthogonal set $\exists x_0 \in X$ such that $\forall y \in X, y \perp x_0$ or $\forall y \in X, x_0 \perp y$
 $\Rightarrow q(x_3) \perp r(x_2) \perp s(x_1) \perp t(x_0)$ [by using condition 1.] ... (i)

Now similarly, we can choose iterated $\{x_n\}$ sequence $\forall n \in \mathbb{N}$ such that

$$q(x_{n+2}) = r(x_{n+1}) = s(x_n) = t(x_{n-1}) \quad \forall n \in \mathbb{N} \quad \dots (ii)$$

Since $\forall x_n \in X, \forall n \in \mathbb{N} \exists q(x_{n+2}) \in X$

So, similarly consider a sequence $\{q(x_{n+2})\}$ and subsequence $\{r(x_{n+1})\}, \{s(x_n)\}$ such that

$$q(x_{n+2}) \perp q(x_{n+1}) \text{ or } q(x_{n+1}) \perp q(x_n) \quad \forall n \in \mathbb{N} \text{ which implies that } \{q(x_{n+2})\} \text{ is orthogonal sequence.} \quad \dots (iii)$$

Then, its subsequences $\{r(x_{n+1})\}, \{s(x_n)\}$ are also orthogonal sequence. ... (iv)

Now let $m, n \in \mathbb{N}$

We obtain $q(x_0) \perp q(x_{n+2})$ or $q(x_{n+2}) \perp q(x_0)$,

$r(x_0) \perp r(x_{n+1})$ or $r(x_{n+1}) \perp r(x_0)$,

$s(x_0) \perp s(x_n)$ or $s(x_n) \perp s(x_0), \forall x_n \in X \forall n \in \mathbb{N}$ and fixed $x_0 \in X$.

By using (ii) equation

We have,

$$p(qx_{n+2}, qx_{n+m+2}) = p(rx_{n+1}, rx_{n+m+1}) = p(sx_n, sx_{n+m}) = p(tx_{n-1}, tx_{n+m-1})$$

By using condition (2.)

$$\leq \psi(p(sx_{n-1}, sx_{n+m-1}))$$

$$\leq \psi'(p(sx_{n-2}, sx_{n+m-2}))$$

$$\leq \psi^n(p(sx_0, sx_m))$$

$$\leq \psi^n(M)$$

Where $M = \text{Sup}\{p(x, y) | x, y \in X\}$

Since $\lim_{n \rightarrow \infty} \psi^n(M) = 0$

Then $\forall n, m \in \mathbb{N}, \forall x_n, x_{n+m} \in X$ such that $s(x_n) \perp s(x_{n+m})$ or $s(x_{n+m}) \perp s(x_n)$

We get $p(sx_n, sx_{n+m}) < 0$

$\Rightarrow \{s(x_n)\}$ is p – Cauchy orthogonal sequence ... (v)





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Then by using [(iii), (iv), (v)], $\{q(x_{n+2}), \{r(x_{n+1})\}$ are p – Cauchy orthogonal sequence

...(vi)

Suppose that $q(x), r(x), s(x)$ are S – complete

$\Rightarrow \exists u \in X, u \perp x_n$ or $u \in X, x_n \perp u, \forall n \in \mathbb{N}$ then

$u \in X, qu \perp qx_{n+2}$ or $qx_{n+2} \perp qu$ such that $\lim_{n \rightarrow \infty} p(qu, qx_{n+2}) = 0,$

$u \in X, ru \perp rx_{n+1}$ or $rx_{n+1} \perp ru$ such that $\lim_{n \rightarrow \infty} p(ru, rx_{n+1}) = 0,$

$u \in X, su \perp sx_n$ or $sx_n \perp su$ such that $\lim_{n \rightarrow \infty} p(su, sx_n) = 0,$

$u \in X, tu \perp tx_{n-1}$ or $tx_{n-1} \perp tu$ such that $\lim_{n \rightarrow \infty} p(tu, tx_{n-1}) = 0,$

Therefore by (v),(vi) $qu = ru = su = tu$

By using lemma 2.7

we get $qu = ru = su = tu$

...(vii)

Now the assumption that q, r, s and t are weakly compatible which implies

$q.ru = r.qu$

$r.su = s.ru$

...(viii)

$s.tu = t.su$

$q.tu = q.ru = r.qu = r.ru = r.tu = r.su = s.ru = s.tu = t.su$ [by (vii) and (viii)]

Suppose that $p(r.ru, ru) \neq 0$

From inequality 2.

It follows $p(r.ru, ru) \leq \psi(p(q.ru, qu))$

$< p(r.ru, ru)$

This led to the contradiction

Thus, $p(r.ru, ru) = 0$

$\Rightarrow r.ru = ru$

$\Rightarrow q.tu = q.ru = r.qu = r.ru = r.tu = r.su = s.ru = s.tu = t.su = ru = tu$

$\Rightarrow tu$ is common fixed point of q, r, s and t .

Now if range of t is S – complete of X

Then $\exists v \in X, v \perp x_n$ or $v \in X, x_n \perp v$ such that $\lim_{n \rightarrow \infty} p(tv, tx_n) = 0$

From condition 1. We have $\exists w \in X, v \perp w$ or $w \perp v$ such that $tv = qw = rw = sw$

And the proof of that tw is a common fixed point of q, r, s and t is same as that given when $q(x), r(x)$ and $s(x)$ is S – complete.

For uniqueness

Suppose $\exists u, v \in X, v \perp u$ or $u \perp v$ is such that $qu = ru = su = tu = u,$

$qv = rv = sv = tv = v$ with $u \neq v$.

Since \perp – preserving $qu \perp qv$ or $qv \perp qu$ and $u \neq v$ implies that $p(u, v) \neq 0$

Then by condition 2. of the theorem and lemma 2.7, follows

$p(u, v) = p(tu, tv)$

$\leq \psi(p(su, sv))$

$\leq \psi(p(ru, rv))$

$\leq \psi(p(qu, qv))$

$= \psi p(u, v)$

$< p(u, v)$

Which is a contradiction

Therefore, $p(u, v) = 0$

This implies $u = v$

Theorem

Let (X, \perp, τ) be a p - bounded Orthogonal Hausdroff topological space with a τ – distance p . Let φ and δ be two \perp – continuous and \perp – preserving weakly compatible self mapping of X . Satisfying the following condition

For every $x, y \in X, \varphi(x) \perp \varphi(y)$ or $\varphi(y) \perp \varphi(x)$ and $\delta(x) \perp \delta(y)$ or $\delta(y) \perp \delta(x)$

1. $\delta(X) \subseteq \varphi(X)$





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$$2. \quad P(\delta x, \delta y) \leq \psi(p(\varphi x, \varphi y)), \text{ where } \psi \in \Psi$$

If the range of φ and δ are S- Complete subspace of X then φ and δ have a unique common fixed point.

Proof: Since X is an orthogonal set $\exists x_0 \in X$ such that $\forall y \in X y \perp x_0$ or $\forall y \in X x_0 \perp y$
 $\Rightarrow \varphi(x_1) \perp \delta(x_0)$ or $\delta(x_0) \perp \varphi(x_1)$ [by using condition 1.] ... (i)

Now similarly, we can choose iterated $\{x_n\}$ sequence $\forall n \in \mathbb{N}$ such that

$$\varphi(x_n) = \delta(x_{n-1}) \quad \forall n \in \mathbb{N} \quad \dots(ii)$$

Since $\forall x_n \in X, \forall n \in \mathbb{N} \exists \varphi(x_n) \in X$

So, similarly consider a sequence $\{\varphi(x_n)\}$ such that

$$\varphi(x_n) \perp \varphi(x_{n+1}) \text{ or } \varphi(x_{n+1}) \perp \varphi(x_n) \quad \forall n \in \mathbb{N}$$

$\Rightarrow \{\varphi(x_n)\}$ is orthogonal sequence.

Now let $m, n \in \mathbb{N}$

We obtain $\varphi(x_0) \perp \varphi(x_n)$ or $\varphi(x_n) \perp \varphi(x_0), \forall x_n \in X \forall n \in \mathbb{N}$ and fixed $x_0 \in X$.

By using (ii) equation

$$\text{We have } p(\varphi x_n, \varphi x_{n+m}) = p(\delta x_{n-1}, \delta x_{n+m-1})$$

By using inequality (2.)

$$\begin{aligned} &\leq \psi(p(\varphi x_{n-1}, \varphi x_{n+m-1})) \\ &\leq \psi'(p(\varphi x_{n-2}, \varphi x_{n+m-2})) \\ &\leq \psi^n(p(\varphi x_0, \varphi x_m)) \\ &\leq \psi^n(M) \end{aligned}$$

Where $M = \text{Sup}\{p(x, y) | x, y \in X\}$

Since $\lim_{n \rightarrow \infty} \psi^n(M) = 0$

Then $\forall n, m \in \mathbb{N}, \forall x_n, x_{n+m} \in X$ such that $\varphi(x_n) \perp \varphi(x_{n+m})$ or $\varphi(x_{n+m}) \perp \varphi(x_n)$

We get $p(\varphi x_n, \varphi x_{n+m}) < 0$

$\Rightarrow \{\varphi(x_n)\}$ is p - Cauchy orthogonal sequence

Suppose that $\varphi(x)$ is S - complete

$\Rightarrow \exists u \in X, u \perp x_n$ or $u \in X, x_n \perp u$ then $\varphi u \in X, \varphi u \perp \varphi x_n$ or $\varphi u \in X, \varphi x_n \perp \varphi u$

such that $\lim_{n \rightarrow \infty} p(\varphi u, \varphi x_n) = 0$

Therefore, $\lim_{n \rightarrow \infty} p(\delta u, \delta x_n) = \lim_{n \rightarrow \infty} p(\delta u, \varphi x_{n+1}) = 0$

By using lemma 2.7

we get $\varphi u = \delta u$

... (iii)

Now the assumption that φ and δ are weakly compatible which implies $\varphi. \delta u = \delta. \varphi u$

$\Rightarrow \varphi. \delta u = \varphi. \varphi u = \delta. \varphi u = \delta. \delta u$ [by (iii)] ... (iv)

Suppose that $p(\delta. \delta u, \delta u) \neq 0$

From inequality 2.

It follows $p(\delta. \delta u, \delta u) \leq \psi(p(\varphi. \delta u, \varphi u))$

$< p(\delta. \delta u, \delta u)$

This led to the contradiction

Thus, $p(\delta. \delta u, \delta u) = 0$

$\Rightarrow \delta. \delta u = \delta u$

Which implies that $\varphi. \delta u = \delta. \varphi u = \delta. \delta u = \varphi. \varphi u = \delta u$ [by (iv)]

$\Rightarrow \delta u$ is common fixed point of φ and δ .

Now if range of δ is S - complete of X

Then $\exists v \in X, v \perp x_n$ or $v \in X, x_n \perp v$ such that $\lim_{n \rightarrow \infty} p(\delta v, \delta v) = 0$

From condition 1.

We have $\exists w \in X, v \perp w$ or $w \perp v$ such that $\delta v = \varphi w$

And the proof of that δw is a common fixed point of φ and δ is same as that given when $\varphi(x)$ is S - complete.

For uniqueness

Suppose $\exists u, v \in X, v \perp u$ or $u \perp v$ is such that $\delta u = u = \varphi u, \delta v = v = \varphi v$ with $u \neq v$.





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Since \perp – preserving $\varphi u \perp \varphi v$ or $\varphi v \perp \varphi u$ and $u \neq v$ implies that $p(u, v) \neq 0$

Then by inequality 2. of the theorem and lemma 2.7, follows

$$p(u, v) = p(\delta u, \delta v)$$

$$\leq (\cdot)$$

$$= (\cdot)$$

$$< (\cdot)$$

Which is a contradiction

Therefore, $(\cdot) = 0$

This implies =

Lemma

Let (\perp, \cdot) be orthogonal metric space and $\theta : X \times X \rightarrow \mathbb{R}^+$ be a function defined by $(\cdot) = (\cdot) - 1 \forall \cdot \perp \perp$ such that $\in \cdot$. Then θ is a θ -distance on X where \perp is the orthogonal metric topology.

Proof: Let (\perp, \cdot) be the orthogonal topological space with the orthogonal metric topology \perp and an arbitrary neighbourhood of an arbitrary $\in \cdot$.

Let $(\cdot) = \{ \cdot \in \cdot, (\cdot) < \cdot, \forall \cdot \in \cdot \perp \perp \}$ is the open ball then $\exists \delta > 0$ such that $(\cdot) \subset \cdot$. Since $(\cdot) - 1 < \cdot$ which implies that $(\cdot) - 1 \subset (\cdot)$,

Let $\in (\cdot) - 1$, $\forall \in \cdot$ such that $\perp \perp$, then $(\cdot) < (\cdot) - 1$, which implies that $(\cdot) < (\cdot)$. Since θ supposed increasing, we get $(\cdot) < \cdot$. Using Theorem 3.2 and Lemma 3.3, we now prove the following Theorem

3.4. Theorem

Let (\perp, \cdot) be a bounded O-complete metric space. Let φ and δ be two weakly compatible self mapping of X . Then $\exists \theta \in \mathbb{R}^+$, such that $\forall \cdot \in \cdot, \perp \perp$ or $\in \cdot, \perp \perp$ implies $\varphi(y) \perp \varphi(x)$ or $\varphi(x) \perp \varphi(y)$ and $\delta(y) \perp \delta(x)$ or $\delta(x) \perp \delta(y)$ satisfying the following conditions:

i) $\delta(X) \leq \varphi(X)$

ii) $\inf_{x \neq y} \{ \theta(d(\varphi x, \varphi y)) - \theta(d(\delta x, \delta y)) \} > 0$

where $\theta \in \Theta$, then φ and δ have a unique fixed point.

Proof: We put $\alpha = \inf \{ \theta(d(\varphi x, \varphi y)) - \theta(d(\delta x, \delta y)) \}$ with $x, y \in X, y \perp x$ or $x \perp y$

Implies $\varphi(y) \perp \varphi(x)$ or $\varphi(x) \perp \varphi(y)$ and $\delta(y) \perp \delta(x)$ or $\delta(x) \perp \delta(y)$

$$\Rightarrow \theta(d(\delta x, \delta y)) \leq \theta(d(\varphi x, \varphi y)) - \alpha \forall x, y \in X$$

$\Rightarrow \varphi(y) \perp \varphi(x)$ or $\varphi(x) \perp \varphi(y)$ and $\delta(y) \perp \delta(x)$ or $\delta(x) \perp \delta(y)$

$$\text{Hence } e^{\theta(d(\delta x, \delta y))} \leq e^{\theta(d(\varphi x, \varphi y)) - \alpha}$$

$$= e^{\theta(d(\varphi x, \varphi y))} \cdot e^{-\alpha}$$

$$= K \cdot e^{\theta(d(\varphi x, \varphi y))} [K = e^{-\alpha}] \text{ Let the function } p: X \times X \rightarrow [0, \infty) \text{ defined by } p(x, y) = e^{\theta(d(x, y))} - 1, \forall x, y \in X \text{ such that } y \perp x \text{ or } x \perp y \text{ which is } \tau_d \text{ - distance on } X \text{ as proved in lemma 3.2 where } \tau_d \text{ is the orthogonal metric topology.}$$

By taking $\psi(t) = Kt$ in theorem 3.1 $\forall t \in [0, \infty)$

We get $p(\delta x, \delta y) \leq K(p(\varphi x, \varphi y)), x \perp y \Rightarrow \varphi x \perp \varphi y$

Finally, we conclude that φ and δ have a unique fixed point.

Example to support our result.

Example

Let $X = [0, 1]$, we define $x \perp y$ if $xy \leq y$ or $xy \leq x$ with $d(x, y) = |x - y|$.

Define $f, g : X \rightarrow X$ by $f(x) = x(x - 1)$ and $g(x) = 0$, for all $x \in X$ and $\theta : [0, \infty) \rightarrow [0, \infty)$, such that $\theta(t) = t^2$, for all $t \in [0, \infty)$. It is easy to see that $g(X) \subset f(X)$ and f, g are weakly compatible. On the other hand, we have for all $x, y \in X$ $\theta(d(fx, fy)) - \theta(d(gx, gy)) = (x^2 - x - y^2 + y)^2 > 0$.

Then f and g satisfy all assumptions of Theorem 3.4 and have the unique fixed point which equal to 0.





CONCLUSION

In this paper, we achieved to prove a common fixed point in an Orthogonal Hausdorff topological space with a τ -distance. Further, we generalized the result for two or more classes of contractive self-mappings in complete orthogonal bounded metric spaces. Then we deduced two fixed point theorems for contractive self mapping in bounded orthogonal complete metric space by proving some lemma. Moreover, to support the proved results we illustrate some example.

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St.Sec Dom Number and St.Co-Sec Dom Number of Two Different Networks

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ABSTRACT

Security issues play in the role of protection of a network from natural or artificial calamities. Designing a network carries both security system and standard connections. Strong secure domination and secure domination varies with degrees. Selection of strong degree nodes as defenders reduces the chance of attackers to attack the network in severe work. Despite having weak degree neighbors, the process of st.sec domination and st.co-sec domination leads to the perfect output for the given data without any fault. The defenders replace the attacked node and the attacked defenders get replaced by its neighbors to ensure the network's process. This article determines a bound for the domination number, strong domination number, st.sec domination number of Aztec Diamond Network and st.co-sec domination number on Icosahedral Triangular Network. Domination number, Strong domination number, st.sec domination number of various graphs is investigated in recent years. But, st.sec dominating sets and st.co-sec dominating sets of dimensional Networks are difficult. In this paper, the vertices are highly examined based on its degrees and its strength of minimum number of guards for protection is included. In this paper, domination is sometimes mentioned as dom.

Keywords: St.sec and strong co- secure domination number, Aztec Diamond Network, Icosahedral triangular Network.





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INTRODUCTION

Aztec Diamond Network

Dominoes can also be referred to as tiles, bones, cards, men, or pieces. Let's pick a $3 \times n$ board and learn about the tiling dominoes. There are now three options to fill using 2×1 dominoes. An Aztec diamond domino is a group of dominoes with a discontinuous interior whose union is the entire Aztec diamond. In other words, they cover the entire Aztec diamond and the dominoes did not overlap. Every domino is a rectangular tile that often has a line between the two square ends on its face. Alexander Von Humboldt is credited with the well-known Arctic Circle Theorem, which states that a random tiling of a huge Aztec diamond tends to remain frozen. He coined the term "Aztec" in 1810 to refer to all those connected to the Mexican state and others by trade, customs, religion, and language. An Aztec diamond of centre (x, y) satisfies, $|x| + |y| \leq n$ in combinatorial mathematics, where n is a fixed integer. In order for x and y to both be half integers. According to [5], there are $2^{n(n+1)/2}$ domino tilings in the Aztec diamond of order n . The Aztec diamond indices were calculated in [7] using leap Zagreb Indices, which are second degree vertices. The Aztec Diamond graph's structure is based on a square lattice, with a vertex in the centre that is regarded as the origin on the x, y plane and half integers taken for x and y . The symbol $AD(n)$ stands for the Aztec Diamond Network. In this research, we calculated the number of dots in x, y plane. $V(G)$ of $AD(n)$ is $2(n+1)^2 + 2(n+1) - 3$, where $n \in \mathbb{N} > 0$. The high level of Aztec diamond can be build from the lower one. Consider 2×2 boards. The extension of second one is by moving the tiles one step in the direction of the arrows upward, downward, left and right. Hence two 2×2 regions appear. Now three 2×2 appear. In particular, dominoes will never end up overlapping after the sliding phase and at the end of the sliding phase, the region left to be filled is a collection of two by twos and so on. To expand to $AD(4)$, we cannot slide straight away because there are some arrows pointing towards each other. Removing those clashing tiles and moving along the arrows randomly leads to more two by twos. In 1979, the formula for the number of tilings of Aztec Diamond was first conjectured by the physicists Grenzing, Carlon and Supp. In 1991, the mathematicians Noam Elkies, Greg Kuperberg, Michael Larsen and James popp published a number of proofs of this wonderful formula [6]. In 2005, Richard and Steve [8] determined a sign – nonsingular matrix of order $n(n+1)$ whose determinant gives $\prod n$.

Icosahedral Triangular Network

Interconnection networks from the base of Topological indices perform in various applications like sensors, surveillance camera, arrangement of a design to data structure etc. The regular Icosahedrons shape is discovered by Athenian Mathematician Theatetus (417 – 369 BC). Other platonic solids were discovered by Plato. Real life application of Icosahedrons are Many viruses, for example Herpes virus have icosahedral shells, Dungeons and dragons die, Scattergories die, Magic 8 Ball answer, Fuller projection map, TDK logo, Grundy Television logo, Sol de la Floor light shade. It is used in demining success or failure of an action. In [9] the domination number of Icosahedral Triangular network is investigated by Miroslava Mihajlov Carevic. It was proved that domination number for $R_{2,3}$ is equal to 2. The upper level of Rhomboidal triangular network is bisection of edges by new edges. The domination number of Icosahedral triangular network for $n = 2^k$ $k \in \mathbb{N} \setminus \{1\}$ is $\gamma(R_{n+1,2n+1}) = 2^{2k-1}$ [9]. The number of divisions of the triangular edges in the network $R_{2,3}$ by n .

St.sec dominating set and St.co-sec dominating set

The graph G considered here are simple and undirected without isolated vertices. The concept of secure domination and co-secure domination was introduced by [1]. In [3], the author characterized Honeycomb Networks with SDN. In [4], st.co-sec dominating set of certain graphs are obtained. Let $X \subseteq V(G)$ be a dominating set and for each $v \in V(G) - X$, there exists a vertex $u \in V(G)$ such that u is adjacent to v and $\deg(u) \geq \deg(v)$ and $(X/\{u\} \cup \{v\})$ is a dominating set. The minimum cardinality of this st.sec domination number is the st.sec dominating set of G . It is denoted by $\gamma_{ssd}(G)$. [1] Let $X \subseteq V(G)$ be a dominating set and for each $u \in V(G)$, there exists a vertex $v \in V(G) - X$ such that u is adjacent to v and $\deg(u) \geq \deg(v)$ and $(X/\{u\} \cup \{v\})$ is a dominating set. The minimum cardinality of this st.sec domination number is the st.co-sec domination number of G . It is denoted by $\gamma_{scsd}(G)$. [1]





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Dominating sets and strong dominating sets of Aztec Diamond Network

Lemma 1.1: The domination number and the strong domination number of AD (1) are 3.

Proof: Consider the graph in an x, y plane and its centre origin is noted as $(0,0)$ with maximum degree 4. In AD (1), $V(G) = 9$. Number of vertices having degree (4) is 1. Thus remaining vertices are dominated by at least two vertices of degree 3. These 4 vertices are independent. The dominating set is denoted as X . The possible dominating sets are

$X = \{(0,0), (0,1), (0, -1)\}; \{(0,0), (1,0), (-1,0)\}$ and $V - X$ vertices are of degree 3 and 2.

The minimum cardinality of the domination number of AD (1) is 3. i.e. $\gamma(AD(1)) = 3$. These dominating vertices also satisfy $\deg(u) \geq \deg(v)$. Therefore $\gamma_{sd}(AD(1)) = 3$.

Lemma 1.2: The domination number of AD (n) = $4n - 2$ where $n = 2, 3, 4$ and the strong domination number is $4n$.

Proof: In AD (2), $V(G) = 21$. One of the possible dominating sets is $X = \{(0,2), (0,1), (-2,0), (2,0), (0, -1), (0, -2)\}$. Therefore $\gamma(AD(2)) = 6$. But the neighborhoods of $u \in X$ has higher degree vertices in $v \in V - X$. Thus $\gamma_{sd}(AD(2)) \neq \gamma(AD(2))$. Let vertices of degree 4 are m , vertices of degree 3 are n , and vertices of degree 2 are l . $\therefore m = 9, n = 4, l = 8$. Consider m vertices as dominating set and $N(m) = 13$. Thus m will be a strong dominating set. But to prove the minimum cardinality, consider the center vertex $(0, 0)$ which is dominated by its neighbors. Rejecting $(0, 0)$ from dominating set leads to $m = 8$. Hence $\gamma_{sd}(AD(2)) = 8$. Similarly for $n = 3$, $\gamma(AD(3)) = 10, \gamma_{sd}(AD(3)) = 12$. For $n = 4$, $\gamma(AD(4)) = 14, \gamma_{sd}(AD(4)) = 16$. AD network on the basis of its properties changes simultaneously from AD (4). Though the no. of vertices increases in the range of multiplication of 4, the domination number and the strong domination number increase arbitrarily less in number. The theorem stated next is the result of finding the strong dominating sets and the dominating sets. From $n = 5$ onwards, both dominating set and the strong dominating set is equal.

Theorem 1.3: The domination number and the strong domination number of AD (n) where $n > 4, n \in N$ is $7n - 13$.

Proof: Label the AD vertices of $n > 4$ consecutively from the center vertex $(0, 0)$ such that $|x| + |y| \leq n$.

Consider AD (5). Now Upper side dominating set is

$D' = \{(-1, 0), (1, 0), (-4, 0), (4, 0), (-4, 1), (-3, 1), (4, 1), (3, 1), (0, 2), (-2, 3), (2, 3), (0, 4), (0, 5)\}$.

Lower side dominating set is

$D'' = \{(-4, -1), (4, -1), (-2, -2), (2, -2), (0, -2), (-2, -3), (2, -3), (0, -4), (0, -5)\}$

Thus $|D'| + |D''| = |D| = 22$.

i.e. $\gamma(AD(5)) = \gamma_{sd}(AD(5)) = 22$. For AD (6), add outer vertices and edges on the border of AD (5) with conditions mentioned in the demonstration of its extension. Addition of $4n + 8$ vertices to AD ($n - 1$) is the number of vertices in AD (n). Two cases are constructed to find the strong dominating sets.

Case (i): Obtaining strong dominating set of AD (n) from strong dominating set of AD ($n - 1$).

Observe that vertices of degree 4 are obviously in the strong dominating set.

The vertices $(0, i), (0, -i), (i, 0), (-i, 0)$ are some dominating vertices in AD(n) and these vertices are the strong dominating vertices in AD($n - 1$) as $(0, i - 1), (0, -(i - 1)), (i - 1, 0), (-(i - 1), 0)$.

Hence $(4n + 8) - 4$ vertices are to be dominated by maximum degree vertices. Add $n + 1$ vertices with degree 4 vertices. For AD (6), $\gamma_{sd}(AD(6)) = \gamma_{sd}(AD(5)) + 7 = 22 + 7 = 29 = 7(6) - 13$. In general, the strong dominating vertices of n are 7 times n with removal of 13 vertices. i.e. $\gamma_{sd}(AD(n)) = 7n - 13$ is the minimum strong domination number of AD (n).

Case (ii): Obtaining strong domination number of AD (n) from its center vertex $(0, 0)$.

Center vertex is of degree 4. Now divide the graph into 4 parts with x, y plane as border of any 2 set. Number of strong dominating vertices in first phase = Number of strong dominating vertices in second phase. From this, even





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number of vertices in first set of strong dominating set is obtained. Remaining vertices in x plane is $2n + 1$. For these vertices, $n = \lfloor \frac{n}{2} \rfloor$ are required which satisfy $\deg(u) \geq \deg(v)$.

Hence $7n - 13$ is the minimum cardinality strong domination number with various possible dominating set in both connected and isolated nodes.

I.e.) $\gamma_{sd}(AD(n)) = 7n - 13$, for $n > 4$ where $n \in \mathbb{N}$.

St.sec dominating set (SSDS) of AD network

Majority of the network designs are failed or unused due to its insecure properties on its connections. Mild leakage or damage or attack on any node stops the whole output. The design of AD network is well known and it is simple to secure the whole nodes with small number of nodes.

Lemma 2.1: The SSDN of AD (1) is 4.

Proof: consider the strong dominating set of this AD as X , where $X = \{(0, 0), (0, 1), (0, -1)\}$.

Now $X \setminus \{0, 1\} \cup \{1, 1\}$ is not a dominating set, $X \setminus \{0, 0\} \cup \{1, 0\}$ is a dominating set,

$X \setminus \{0, 0\} \cup \{-1, 0\}$ is a dominating set, $X \setminus \{0, -1\} \cup \{1, -1\}$ is not a dominating set,

$X \setminus \{0, -1\} \cup \{-1, -1\}$ is not a dominating set.

Thus $\gamma_{sd}(AD(1)) \neq \gamma_{ssd}(AD(1))$. Adding $(1, 0)$ to the strong dominating set satisfies the st.sec dominating set.

Therefore $\gamma_{ssd}(AD(1)) = 4$.

Lemma 2.2: The SSDN of AD (2) is 9.

Proof: The minimum st.sec dominating set obtained from this graph is independent.

Remark 2.4: In general, $\gamma_{sd}(G) \leq \gamma_{ssd}(G)$ [1]

Here $\gamma_{sd}(G) < \gamma_{ssd}(G)$ for AD (n), $n \in \mathbb{N} > 1$.

Theorem 2.5: The st.sec domination number of AD (n) where $n \in \mathbb{N} > 1$ is

$$\gamma_{ssd}(AD(n)) = 9 + 8(n - 2)$$

Proof: The strong dominating set itself is not the st.sec dominating set and $\gamma_{sd}(G) < \gamma_{ssd}(G)$. Let the dominating set be X . let $u \in X$ and $v \in V - X$. We have to prove each vertex in $V - X$ when defected should be replaced by a vertex in X and the $\deg(u) \geq \deg(v)$. some neighbors of X belongs to $V - X$ will have $\deg(u) < \deg(v)$. It is determined that those nodes are on the exact x and y plane are special. I.e.) some nodes on $X = (0, i), (0, -i), (i, 0), (-i, 0)$ where $i, -i \in \mathbb{N}$ and $i = n - i$. $N(X) = \{(0, i - 1), (0, -i - 1), (i - 1, 0), (-i - 1, 0)\}$ whose degrees are higher than X . Therefore it is impossible to replace these by X . But these Nodes are also neighbors of $\{(0, i - 2), (0, -i - 2), (i - 2, 0), (-i - 2, 0)\}$. So these nodes are mandatory for $N(X)$ and these nodes are also in X is important. This is the initial condition on choosing nodes as strong securities on x, y plane. Fixing AD (2) st.sec dominating sets for all AD (n). Remaining nodes are subdivided as 4 portions. Hence minimalism results in $8(n - 2)$. Therefore $\gamma_{ssd}(AD(n)) = 9 + 8(n - 2)$. On the contrary, let the minimum cardinality of the st.sec domination number of AD (n) be $9 + 8(n - 3)$.

Let $n = 3$; $V(AD(3)) = 37$.

$$\Rightarrow \gamma_{ssd}(AD(3)) = 9 + 8(3 - 3) = 9.$$

In AD (3) has no. of. Vertices with degree 4 is 21; no. of. Vertices of degree 3 is 4; no. of. Vertices with degree 2 are 12. Now 9 vertices with degree 4 can dominate 36 vertices.

$$V(AD(3)) = 37 > 36.$$

For the secure process, the first condition is that all the vertices in $V - X$ should be dominated by vertices in X . Hence our assumption is wrong and therefore $\gamma_{ssd}(AD(n)) = 9 + 8(n - 2)$ is the minimum cardinality of St.sec domination number of Aztec Diamond Network.

St.co-secdomination number of Icosahedral Triangular Network:

Here we denote the Icosahedral Triangular Network of n by $IT(n)$ where we denote the terms as $(R_{n+1, 2n+1})$ for $n \geq 1$.

Lemma 3.1: For $n = 1$, the st.co-secdomination number of IT network is 2 where $IT(1)$ is $R_{2, 3}$.





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Proof: We know that the minimum st.secdomination and st.co-secdomination number for any graph is 2. The minimum strong dominating sets of $R_{2,3}$ are $D = \{R_{12}, R_{13}\}$ or $\{R_{21}, R_{22}\}$. These are the vertices with higher degree. Let $u \in D$ and $v \in V - D$. we have to prove that these strong dominating sets satisfy $D \setminus \{u\} \cup \{v\}$ is a dominating set.

Case (i): $D = \{R_{12}, R_{13}\}$

$N(R_{12}) = \{R_{11}, R_{13}, R_{21}, R_{22}\}$; $N(R_{13}) = \{R_{12}, R_{22}, R_{23}\}$ where N denotes the neighborhoods. If the node R_{12} or R_{13} get attacked, then to rescue the remaining nodes, at least one of its neighbor node is considered without any change in domination process.

Now $D \setminus \{R_{12}\} \cup \{R_{22}\}$ is not a dominating set, $D \setminus \{R_{12}\} \cup \{R_{11}\}$ and $D \setminus \{R_{12}\} \cup \{R_{21}\}$ are dominating sets. Similarly, $D \setminus \{R_{13}\} \cup \{R_{23}\}$ is a dominating set.

It is not possible for R_{22} to replace R_{13} since $\deg(u) < \deg(v)$.

Case (ii): $D = \{R_{21}, R_{22}\}$

$N(R_{21}) = \{R_{11}, R_{12}, R_{22}\}$; $N(R_{22}) = \{R_{12}, R_{13}, R_{21}, R_{23}\}$ where N denotes the neighborhoods. If the node R_{21} or R_{22} attacked, then to rescue the remaining nodes, at least one of its neighbor nodes is considered without any change in domination process.

Now $D \setminus \{R_{21}\} \cup \{R_{11}\}$ is a dominating set, $D \setminus \{R_{22}\} \cup \{R_{13}\}$ is a dominating set.

It is not possible to replace R_{21} by R_{22} since $\deg(u) < \deg(v)$.

Hence from above cases, the minimum st.co-secdomination number of $IT(1)$ is 2. i.e.) $\gamma_{scsd}(IT(1)) = 2$.

Lemma 3.2: For $R_{3,5}$, the st.co-secdomination number of IT network is 5.

Proof: The domination number of $R_{3,5}$ is 3.

i.e) $D = \{R_{21}, R_{23}, R_{25}\}$ is one of the possible dominating set.

Now the nodes in the centre path are $R_{21}, R_{22}, R_{23}, R_{24}, R_{25}$. These nodes are of degree higher than or equal to 4. Let the 3 nodes in D are to be st.co-sec dominating set. Suppose R_{21} is defected, then its neighbor R_{22} is not possible to replace as it has degree greater than R_{21} . Replacing R_{21} by R_{12} or R_{21} by R_{31} or R_{21} by R_{11} is not a dominating set. Hence the dominating set itself is not st.co-sec dominating set.

Let $D_1 = \{R_{21}, R_{22}, R_{23}, R_{24}, R_{25}\}$. Now to find neighbor nodes to these attacked nodes.

$D_1 \setminus \{R_{21}\} \cup \{R_{11}\}, D_1 \setminus \{R_{22}\} \cup \{R_{31}\}, D_1 \setminus \{R_{23}\} \cup \{R_{33}\}, D_1 \setminus \{R_{24}\} \cup \{R_{15}\}, D_1 \setminus \{R_{25}\} \cup \{R_{35}\}$ are dominating sets. Thus D_1 is the st.co-sec dominating set.

To prove the minimum cardinality, Let $D_2 = \{R_{21}, R_{23}, R_{24}, R_{25}\}$

Here R_{21} neighbors $R_{11}, R_{22}, R_{12}, R_{31}$ fail to replace and satisfy the dominating set when R_{21} get attacked. Also any of these sets of D 's with 4 nodes do not satisfy the dominating set.

Hence $\gamma_{scsd}(R_{3,5}) = 5$.

Remark 3.3: $\gamma_{sd}(IT(n)) < \gamma_{scsd}(IT(n))$ for $n > 1$ where $IT(n)$ is $(R_{n+1}, 2n+1)$

In the next theorem, the extension of the summation of (2^{2k-i}) always ends at 2^5 with addition to remaining number of strong dominating vertices.

Theorem 3.4: If $n = 2^k$, then

$$\sum_{i=1,3,5} 2^{2k-i} + k - 2 + \gamma_s(R_{5,9}) = \gamma_{scsd}(R_{n+1}, 2n+1)$$

Proof

The structure of Icosahedral Triangular Network is the development of splitting of origin $R_{2,3}$ network. From lemma of $n = 2^2$ and $n = 2^3$, we can derive the st.secdomination number of $n = 2^k$. In $n = 2^k$, where $k = 2$, the strong dominating set is $D = \{R_{14}, R_{21}, R_{26}, R_{28}, R_{42}, R_{44}, R_{49}, R_{56}\}$ The vertex $\{R_{21}\}$ is dominating its neighbours. But when attacked, none of its neighbours will replace to continue the process.





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le) $D \setminus \{R_{21}\} \cup$ any one of its neighbours is not a dominating set, $D \setminus \{R_{14}\} \cup$ any one of its neighbours is not a dominating set. Therefore $\gamma_s(R_{5,9}) \neq \gamma_{scsd}(R_{5,9})$

To this strong dominating set, add 8 more vertices whose degrees are higher than or equal to its neighbours.

Let the st.co-sec dominating set be D' .

The nodes of D' are $\{R_{14}, R_{21}, R_{23}, R_{26}, R_{28}, R_{34}, R_{38}, R_{41}, R_{42}, R_{44}, R_{46}, R_{49}, R_{56}, R_{58}\}$

Therefore $|D'| = 14 = \gamma_{scsd}(R_{5,9})$

Now vary with this numbers with respect to power of 2,

$$\Rightarrow 2^4 - 2 = 14.$$

$$\text{Similarly, } \gamma_{scsd}(R_{9,17}) = 47 = 2^5 + 2^4 - 1$$

$$\gamma_{scsd}(R_{17,33}) = 176 = 2^7 + 2^5 + 2^4$$

$$\gamma_{scsd}(R_{33,65}) = 689 = 2^9 + 2^7 + 2^5 + 2^4 + 1$$

Continuing in this procedure, we get

$$\gamma_{scsd}(R_{n+1, 2n+1}) = \sum_{i=1,3,5} 2^{2k-i} + k - 2 + \gamma_s(R_{5,9})$$

Example 3.5: The st.co-secdomination number of $R_{3,5}$ is 5.

The oval dots are st.co-secdomination numbers of this network.

CONCLUSION

The aim of this research is to optimize active movable guards in securing valuable networks in the form of Aztec Diamond and Icosahedral triangular Networks. The major application is to replacing the defected systems with suitable relative systems without stopping the whole process. Immediate replacement option to continue crucial position values more in both time and output. This can be extended to other suitable networks related to chemical graphs, computational graphs and networks.

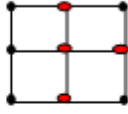
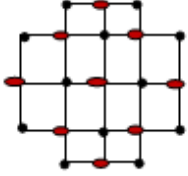
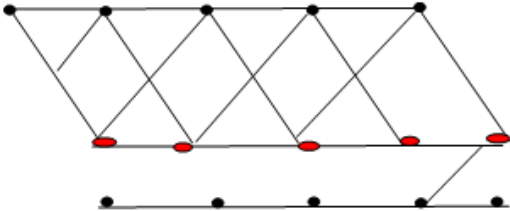
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<p>Fig:1</p>	<p>Fig:2</p>
	
<p>Fig:3 Icosahedral Triangular Network $R_{3,5}$</p>	





Simultaneous Estimation of Dolutegravir and Lamivudine in Bulk and Tablet Formulation by Validated New UV Spectroscopic Methods

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ABSTRACT

A Simple, sensitive and specific UV methods were developed for simultaneous estimation of Dolutegravir and Lamivudine in bulk and tablet dosage form. Effective analysis was done by simultaneous equation, isobestic point and Q-absorbance ratio method by using acetonitrile and water (1:1) solvent system. The 258nm and 271nm were adopted in simultaneous equation method. The 260nm wavelength used in isobestic point and Q-absorbance ratio method. The developed methods were validated as per ICH Q2(R1) provisions. The developed methods were linear in the concentration range of 5-30 µg/mL for Dolutegravir and Lamivudine. The given concentration series was obeying the Beer's-Lambert's law limits. Accuracy studies for Dolutegravir and Lamivudine were done and the % recovery for Dolutegravir and Lamivudine was obtained in the range of 98.35-100.51% by all the methods assuring the accuracy of the stated UV method. All the methods have shown good precision and robustness with %RSD less than 2. The data have been statistically validated, and the results demonstrate that the methods that have been proposed can be implemented effectively for the regular evaluation of drugs in commercialized tablets.

Keywords: Lamivudine, Dolutegravir, Simultaneous equation, Isobestic Point, Q- Absorbance, Specific Absorptivity.



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INTRODUCTION

Analytical methods are essential in maintaining the quality and quantity of drugs in drug products, as well as in the formulation development process because they help to maintain the quality and efficiency of the drug product throughout the product development process until its final [1,2]. The breakthrough in HIV medicine has allowed people to live for longer periods of time and to live more productive lives. To effectively treat HIV, multi drug therapy (which involves taking three or more drugs alone or in combination daily) is used [2]. However, thorough studies on multiple drug therapy have demonstrated that a two-drug treatment consisting of Lamivudine (LMV) and Dolutegravir (DLG) effectively controls the HIV disease[3,4]. DLG, a second-generation antiretroviral agent, gained approval from US FDA in 2013 for treating HIV infections in all populations [4,5]. DLG is an effective second-generation integrase strand transfer inhibitor (INSTI) used in HIV-1 patients to prolong the survival period. It acts by inhibiting the integration of viral DNA into the DNA material of host (T-cells)[4-6]. Chemically DLG is (4R,12aS)-N-[(2,4-Difluorophenyl)methyl]-3,4,6,8,12,12a-hexahydro-7-hydroxy-4-methyl-6,8-dioxo-2H-pyrido [1',2':4,5] pyrazino[2,1-b][1,3]oxazine-9-carboxamide [6]. Lamivudine is a classical antiviral agent used in HIV-1 patients alone or in co-formulation with other antiviral agents [7]. LMV triphosphate (3TCTP) is the active moiety of LMV competitively inhibits the reverse transcriptase enzyme leads to termination of viral genome replication [8]. Chemically LMV is 4-amino-1-[(2R, 5S)-2-(hydroxyl methyl)-1, 3-oxathiolan-5-yl]-1, 2-dihydropyrimidin-2-one [8]. DLG co-formulated with LMV combination is a potent regimen showing high therapeutics index [9]. (Figure 1: Chemical structures of Dolutegravir and Lamivudine)

A detailed literature review found that two UV methods have been described for estimating LMV and DLG in pharmaceutical dosage forms [10,11]. Few UV-Visible spectroscopic methods were reported for individual estimation of DLG and LMV [12-15]. Simultaneous estimation of intended analyte with other antiviral agents by UV method were available in literature [16-20]. Few RP-HPLC methods for estimating LMV, DLG, Tenofovir disoproxil fumarate, Butcaver sulfate, or Abacavir in the triple combination [21-24]. Few Liquid chromatographic methods were reported for analysis of LMV and DLG simultaneously in both bulk mixture and combined tablets [25,26]. To date, no UV method approach has been published in the literature for the simultaneous measurement of LMV and DLG in bulk and tablet dosage forms by simultaneous equation, isobestic point and Q-absorbance method. As a result, we are researching to create an effective, sensitive, and economically feasible UV approach for estimating the % purity of DLG and LMV in bulk and tablet dosage forms at the same time by simultaneous equation, isobestic point and Q - Absorbance ratio methods [27]. The Q2 specification of the ICH guidelines validated the created approach.

MATERIALS AND METHODS

API of LMV and DLG were provided by fortune pharma, Telangana as gift sample. AR grade acetonitrile, methanol, Milli-Q and remaining chemicals were obtained from Merck India, Mumbai, India. Absorbance measurements were made using Shimadzu (U-1900) UV/Visible spectrophotometer coupled with UV- probe data acquisition software.

Method Development

Selection of Solvent

The study investigated the solubility of DLG and LMV in different solvents, including water, methanol, and acetonitrile. The results showed that the DLG was highly soluble in acetonitrile and methanol, while it exhibited poor solubility in water. Similarly, the solubility of LMV was assessed in the same solvents and was found to have good solubility in water, methanol and acetonitrile. Based on its cost-effectiveness and safety profile, acetonitrile and water in 1:1 ratio was chosen as the preferred solvent for dissolving the drug.





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Preparation of Stock Solution (1000µg/ml)

Accurately weighed quantity of pure DLG (100mg) and pure LMV (100mg) were transferred into two separate 100 ml volumetric flasks, dissolved with the solvent system of acetonitrile and water (1:1) and made up to 100 ml with same solvent to give solution containing 1000µg/ml. The solution was sonicated for 5mins.

Preparation of Working Standard (100µg/ml)

10ml of the stock each stock solution was taken and transferred to another separate 100ml volumetric flask and the same solvent system was added up to 100ml for additional dilution to give a solution containing 100µg/ml.

Determination of Absorption Maxima (λ_{max}) and Isobestic Point of DLG and LMV

10µg/ml of DLG and LMV solution were prepared by diluting 1ml of working standard solution again diluted to 10 ml with the same solvent system. The produced solutions of DLG and LMV were scanned in the UV spectrophotometer from 400-800nm to determine the λ_{max} of given compounds. The λ_{max} of DLG and LMV were observed to be 258nm and 271nm, correspondingly (Figure-2). The isobestic point of DLG and LMV confirmed at 260nm from the attained spectrum (Figure-2).

(Figure 2: Absorption Maxima and Isobestic Point Dolutegravir and Lamivudine)

Simultaneous Equation Method

Standard solutions of DLG and LMV in the concentration range of 5-40µg/mL and 5-40µg/mL respectively was prepared and the absorbance of these solutions was measured at 258 nm and 271 nm. Calibration curves were plotted to verify the Beer's law and the absorptivity values (calculated at the respective wavelengths for both the drugs. Two simultaneous equations as below were formed using these absorptivity values.

$$A_1 = 410C_x + 170C_y$$

$$A_2 = 310C_x + 230C_y$$

Where, C_x and C_y are the concentrations of DLG and LMV measured in gm/100mL in sample solutions. A_1 and A_2 are the absorbances of mixture at selected wavelengths 258 nm and 271 nm respectively.

Absorbance Ratio Method/ Q-Analysis

The absorbance ratio method is a modified version of the simultaneous equation procedure based on the principle that for a substance that follows Beer's law at all wavelengths, the absorbance ratio at any two wavelengths remains constant and independent of concentration or path length. This ratio is referred to as the Q value in the USP. In the quantitative assay of two components in admixture, the absorbance's are measured at two wavelengths - one at the λ_{max} of one of the components (λ_2) and the other at an iso-absorptive or isobestic point (λ_1) where the absorptivity of both components is equal. To validate Beer's law, a series of standard solutions of DLG and LMV in the concentration range of 5-30µg/mL and 5-30µg/mL, respectively, were prepared in phosphate buffer, and their absorbance was measured at 258nm and 260 nm (λ_{max} of CPX). The data was used to plot calibration curves, and absorptivity values (g/100ml) were calculated for both drugs at their respective wavelengths. The resulting absorptivity values were reported.

The concentration of two drugs in mixture was calculated by using the following equations:

$$C_x = \frac{Q_m - Q_y}{Q_x - Q_y} \times \frac{A_1}{a_{x1}}$$

$$C_y = \frac{Q_m - Q_x}{Q_y - Q_x} \times \frac{A_1}{a_{y1}}$$

Where, A_1 and A_2 are the absorbance's of dug mixture at 260nm and 271nm, a_{x1} (440), a_{x2} (310) and a_{y1} (480), a_{y2} (230) are A (1%, 1 cm) of DLG and LMV at 260nm and 271nm respectively,

$Q_m = A_2 / A_1, Q_x = a_{x2} / a_{x1}$ and $Q_y = a_{y2} / a_{y1}$



**Method validation****Linearity**

The method's linearity means concentration immediately affects test findings. The linearity of the current approach was tested by measuring absorbance values at 258nm and 271nm for DLG and LMV concentrations from 5 to 30 µg/mL. Finally, concentration-absorbance linearity graph was plotted and regression coefficient (R^2) calculated.

Precision

Precision studies were conducted to evaluate intraday and interday variations of FEX and MKT formulations at three distinct concentrations. Each concentration was prepared thrice and subjected to analysis. The assay was computed for each preparation and the corresponding %RSD) is presented.

Accuracy

The recommended method's accuracy was verified through the standard addition method at 75%, 100%, and 125% concentrations. This involved adding different concentrations of pure drug solutions to a predetermined amount of the DLG and LMV tablet sample (10µg/mL) and measuring the absorbance at the respective wavelengths. The analysis of the percentage recovery at each level was conducted through the utilization of both methods.

Specificity

Specificity refers to the capability of the method to accurately detect the analyte in the presence of other potentially interfering components. The specificity of the developed method for determining DLG and LMV in tablet dosage form was assessed by comparing the spectral characteristics of the tablet solution to those of the standard solution. The sample spectrum was thoroughly examined to identify any potential interferences arising from the presence of excipients.

Robustness

The maximum absorption wave length were purposely changed to test the method's resilience. After changing the wavelength maximum (± 2 nm), % RSD can be evaluated for obtained absorbance values.

Sensitivity

Standard deviation equations were utilized to calculate LOD and LOQ.

$$\text{LOD} = 3 \times \sigma / S$$

$$\text{LOQ} = 10 \times \sigma / S$$

Where, σ is the standard (SD) of the intercept

S -slope of the linear plot

Sandell's sensitivity

Sandell's index or sensitivity is the lowest concentration in ppm ($\mu\text{g}/\text{cm}^3$) with absorbance of 0.001 in a 1 cm path length. Calculated as:

$$\text{Sandell's index} = (0.001 \times 1\text{cm}) / \text{slope} (\text{cm}^3 / \mu\text{g})$$

Assay of tablets

20 tablets (DOVATO) of DLG and LMV were processed and powder equivalent to 10 mg of DLG and 30 mg of LMV was measured and then transferred to a 100 ml volumetric flask, mixed with an adequate solvent (ACN: Water, 1:1), sonicated for 5 min, and made up to the mark with same solvent. From this 1 ml diluted to 10 mL with identical solvent, the sample solution absorbance was measured at 258 nm and 271nm.



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RESULTS AND DISCUSSION

The optimized method conditions such as ACN: water in equal portions, λ_{\max} of 258nm (DLG), 271nm (LMV), and isobestic point of 260nm were used to validate the stated method as of ICH. The DLG and LMV solutions were shown linearity with a concentration range from 5 to 30 μ g/mL. The given series of solutions were acceptable R^2 values at 258nm, 271nm and 260nm (Table-1, Figure-3). To the stated concentration series (5 to 30 μ g/mL) intraday and intermediate precisions were validated by computing the %RSD values, which assured the precision of the method (Table-2). The % recoveries of DLG and LMV in spiked solutions were observed to be 100 \pm 2% (Table-3). Potential changes were not happened in the UV spectrum of pure drug in comparison with tablet sample solution. Hence, the method was specific towards DLG and LMV. Slight modification in the wavelengths of optimized method could not affect the %RSD values of absorbance's (Table- 4). The LOD, LOQ and Sandell's sensitivity values of DLG and LMV were shown in Table-5. Those results were demonstrating the good sensitivity of the given approach. The % purities of the DLG and LMV in given tablets (DOVATO) were found to be 99.21 \pm 1.2% and 98.63 \pm 0.98% by simultaneous equation approach and 99.78 \pm 1.31% and 100.81 \pm 1.65% by Q- absorbance ratio method respectively.

As per literature only one UV methods was reported in literature for analysis of DLG and LMV. Rathod et al., was proposed first order derivative UV method for assessment of DLG and LMV[10]. The present method was designed in such a way to analyze DLG and LMV simultaneously by various predominated methods like simultaneous equation, isobestic point and Q-absorbance methods. The stated methods are obeying the Beer's- Lambert's law with given concentration. The possessed methods have superior sensitivity than the reported method. Simple solvent system made the method economical. Hence, the develop UV methods have good adoptability in pharmaceutical sector in regular analysis of DLG and LMV combined tablets.

CONCLUSION

Two new UV spectrophotometric techniques such as simultaneous equation, isobestic point and Q-absorbance analysis that are easy to use, sensitive, and cost-effective have been developed for the simultaneous measurement of DLG and LMV in bulk as well as in tablet formulations. Following successful validation of the methods that were created, it was determined from the statistical data that the approaches were linear, accurate, and exact, and that they are capable of being effectively employed for the study of table formulations without the interference of excipients.

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Table-1: Linearity results of DLG and LMV with a concentration range from 5 to 30µg/mL

Concentration (µg/ml)	DLG	LMV	DLG	LMV		
	258nm	271nm	258nm	271nm	260nm	260nm
5	0.25	0.15	0.11	0.14	0.23	0.26
10	0.41	0.31	0.17	0.23	0.44	0.48
15	0.54	0.47	0.23	0.31	0.51	0.56
20	0.72	0.63	0.3	0.41	0.75	0.71
30	0.99	0.92	0.41	0.59	0.98	0.98
Slope	0.029	0.030	0.012	0.018	0.027	0.028
Intercept	0.106	0.002	0.050	0.047	0.183	0.131
R ²	0.998	0.999	0.998	0.999	0.998	0.998

Table-2: Precision results of DLG and LMV

CONC (µg/ml)	Dolutegravir				Lamivudine			
	258nm		271nm		258nm		271nm	
	*Mean±SD	%RSD	Mean±SD	%RSD	Mean±SD	%RSD	Mean±SD	%RSD
5	0.21±0.001	0.47	0.15±0.0032	1.33	0.12±0.002	1.6	0.13±0.002	1.53
10	0.39±0.006	1.53	0.31±0.006	1.93	0.18±0.003	1.6	0.24±0.004	1.66
15	0.52±0.004	0.76	0.47±0.009	1.91	0.24±0.001	0.41	0.32±0.003	0.93
20	0.73±0.005	0.68	0.63±0.004	0.63	0.32±0.004	1.25	0.44±0.005	1.13
30	0.98±0.009	0.91	0.92±0.01	1.08	0.42±0.006	1.42	0.61±0.007	1.14

*Absorbance of six replicates

Table-3: % Recovery of DLG and LMV at 258nm,271nm and 260nm

Drug Name	λmax	50% Level (10 µg/mL)		100% Level (20µg/mL)		150% Level (30 µg/mL)	
		Recovered (µg/mL)	% Recovery	Recovered (µg/mL)	% Recovery	Recovered (µg/mL)	% Recovery
DLG	258nm	9.92	99.2	19.67	98.35	30.1	100.33
	271nm	10.03	100.3	20.05	100.25	30.12	100.4
LMV	258nm	10.01	100.1	19.92	99.6	29.78	99.26
	271nm	9.87	98.7	19.85	99.25	29.74	99.13
DLG	260nm	9.89	98.9	19.93	99.7	30.16	100.51
LMV	260nm	9.91	99.1	20.09	100.31	29.81	99.31

Table-4: Robustness of DLG and LMV at 258nm,271nm and 260nm

Parameter	DLG				LMV			
	260nm	256nm	273nm	269nm	260nm	256nm	273nm	269nm
Mean	0.44	0.43	0.33	0.28	0.18	0.19	0.23	0.21
SD	0.005	0.004	0.003	0.001	0.002	0.003	0.004	0.001
%RSD	1.13	0.93	0.90	0.35	1.11	1.57	1.73	0.47





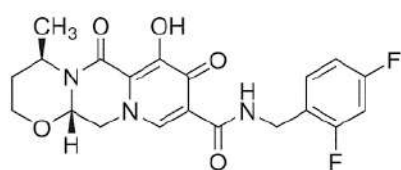
Ramreddy Godela et al.,

Table-5: Sensitivity of DLG and LMV at 258nm,271nm and 260nm

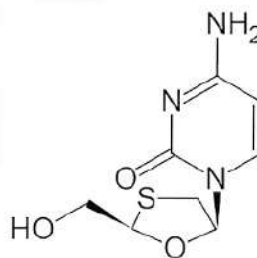
Parameter	DLG		LMV		DLG	LMV
	258nm	271nm	258nm	271nm	260nm	260nm
LOD(µg/ml)	0.28	0.27	1.58	0.94	0.21	1.12
LOD(µg/ml)	0.94	0.91	5.0	3.10	0.694	3.69
Sandell's sensitivity	0.03	0.03	0.08	0.05	0.03	0.04

Table-6: % assay of DLG and LMV by different methods

%Assay (Mean=6)	Simultaneous equation method		Q-Absorbance method		Isobestic point method		Label claim (mg)	
	DLG	LMV	DLG	LMV	DLG	LMV	DLG	LMV
	99.21	98.63	99.78	100.81	100.91	99.56	50	300
SD	1.2	0.98	1.31	1.65	0.92	1.41		
%RSD	1.20	0.99	1.31	1.63	0.91	1.42		



Dolutegravir



Lamivudine

Figure 1: Chemical structures of Dolutegravir and Lamivudine

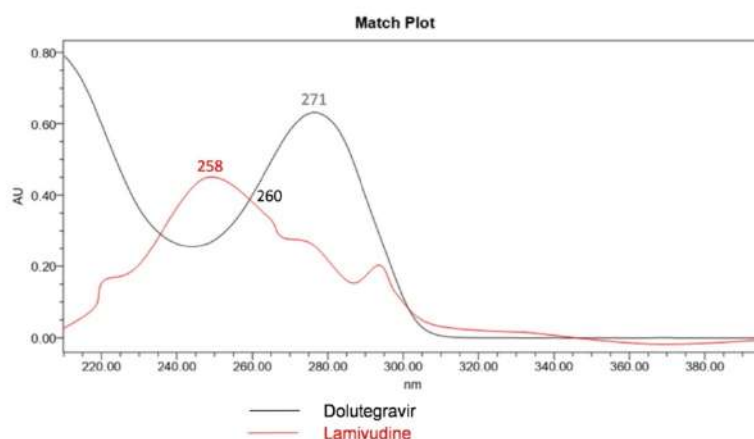


Figure 2: Absorption Maxima and Isobestic Point Dolutegravir and Lamivudine





Ramreddy Godela et al.,

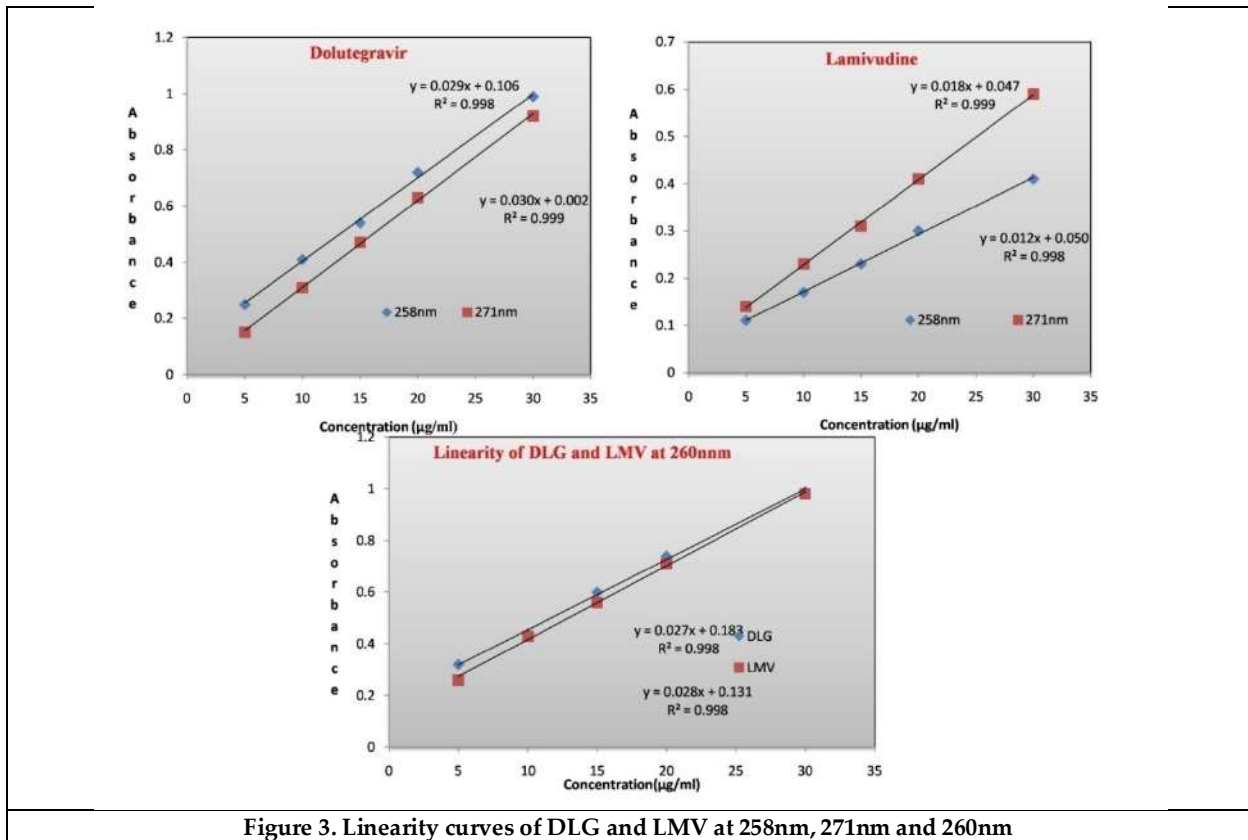


Figure 3. Linearity curves of DLG and LMV at 258nm, 271nm and 260nm





Navigating Man-in-the-Middle Vulnerabilities: Understanding, Defenses and Forward Strategies

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ABSTRACT

The constant evolution of PC structures and applications facilitates continuous data processing, leading to the emergence of new cyberattacks, such as the eaves dropping MiTM attack. In this scenario, an external assailant clandestinely eavesdrops on the exchange of data between two online individuals, facilitating unauthorized entry into and alteration of confidential data without the individuals' knowledge or consent. This paper aims to delve into the intricacies of MITM attacks, including their various forms, mitigation strategies, and future research directions, to address this critical issue effectively.

Keywords: Data Security, Digital Assaults, MITM Assaults, Organization Security.

INTRODUCTION

The internet has integrated itself into our daily lives, becoming indispensable in today's modern world, shaping our routines and interactions. From mobile connectivity to social media dominance, online banking, and shopping, our dependence on the web is undeniable. However, with the advancement of web technology comes an increased risk of cyber threats, with hackers targeting businesses to retrieve confidential sensitive information, leading to potential financial losses. Among these threats, the MiTM attack poses a significant danger to security of networks. In this type of attack, the hacker intercepts communication between two parties, often without their knowledge, exploiting various channels such as GSM, Wi-Fi, UMTS, and Bluetooth. The goal of the attacker extends beyond mere eavesdropping; they seek to manipulate data integrity, spread misinformation, and disrupt communication channels. MITM attacks can compromise both the confidentiality and integrity of data, leading to serious consequences for unsuspecting users. Various terms such as MiM, MitM, MTIM are used interchangeably to refer to this pervasive



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threat. A prevalent example of such incidents is commonly referred to as strong snooping, wherein adversaries establish unauthorized connections with the parties involved and insert themselves in the middle of the communication, effectively intercepting messages between them. To tamper with the messages, the attacker can intercept them as they pass between the two parties. Many cryptographic systems utilize endpoint authentication to address MITM attacks. These incidents can be categorized into four primary groups. The primary categorization includes Man-in-the-Middle (MITM) attacks based on spoofing, wherein the assailant disrupts communication between two entities by employing spoofing techniques, manipulating the communication without leaving any trace to deceive the unsuspecting parties. In some cases, attackers employ various methods such as DNS spoofing to impersonate endpoints or devices. Additionally, TLS/SSL attacks involve the attacker becoming part of the communication between two endpoints, intercepting, and altering the communication undetected. Another example is the BGP MITM attack, where the attacker redirects traffic to their intended target, known as IP hijacking, rerouting traffic through a controlled intermediary. Lastly, there are deceptive base station attacks, where attackers set up fake base stations to control the traffic of unsuspecting victims. MITM resembles a game of catch between two individuals, with a third party attempting to intercept the ball. This paper addresses various forms of spoofing attacks and explores future prospects in the field.

SPOOFING BASED MITM ATTACKS

Caricaturing comes from "snoop," a phrase for European spies who made up identities to listen in on private conversations. Attackers introduce themselves into communication between two parties to manipulate data flow without the victims' knowledge in modern spoofing. Upon encountering an encrypted network that presents as an unfamiliar MAC address, the server initiates an Address Resolution Protocol (ARP) request to all connected clients. Active web display clients usually respond with their Mac address. ARP caching without authentication might generate phony ARP messages, giving attackers gateways. Man-in-the-Middle (MITM) attacks jeopardize sensitive information and interrupt communication by altering message content. Manufacturers regularly upgrade security to prevent MITM attacks. Under optimal circumstances, the attacker "Z" (IP=10.0.y.y.3, MAC address=FF:FF:FF:Y3) manipulates the ARP table of the victim "M" by transmitting a falsified ARP response. Consequently, communications intended for "M" from victim "D" (IP=10.0.y.y.1, MAC address=CC:CC:CC:Y1) are rerouted to "Z," disrupting communication. Despite genuine address updates, "M" adheres to protocol. Refer to the figure below for a visual representation of the described scenario.

ARP SPOOFING

These activities facilitate the mapping of network conversations to specific Mac addresses. ARP plays a crucial role as a foundational and indispensable method for LAN configurations. Attackers take advantage of neighboring ARP cache tables, replacing the host's MAC address with the target IP address, aiming to gain unauthorized access to the client's sensitive data. ARP spoofing attacks typically fall into two main categories: host impersonation and gateway impersonation within the internal network. When a user endeavors to establish a connection with another user possessing an unknown Mac address within the same network, a data transmission is initiated. Such transmissions occur when ARP functions are active within the network. Due to the absence of authentication mechanisms, manipulating cache entries becomes straightforward. The source device can optimize data transmission efficiency during connection periods by retaining IP-to-Mac mappings in the cache. Despite its importance at the network layer, ARP lacks robust security measures within its masking scheme.

Identifying ARP spoofing

Below are outlined several techniques for detecting ARP spoofing

Cryptographic solutions

A significant advancement in combating ARP spoofing is S-ARP [8], which employs metropolitan key cryptography to authenticate ARP responses. These cryptographic methods validate a client's authenticity, thereby thwarting ARP spoofing attacks effectively. P-ARP represents a notable variation of this method with a strong emphasis on security. To authenticate the information, both the magic number and HMAC hash function must be incorporated.



**Imran Qureshi and Shadab****Voting-based solutions**

A robust framework against VB impersonation is provided by MR-ARP. When MR-ARP detects the presence of ARP response or request messages, it verifies whether the device is using the new IP address.

Solutions based on server-side implementations.

A non-cryptographic solution, referred to as 'fix,' has been proposed to address ARP spoofing. This method mandates that the legitimate owner of the IP address intervenes in the event of a MAC address conflict, thereby thwarting ARP spoofing attempt.

Host-based solutions

Host-based solutions, such as middleware, offer a method for handling asynchronous requests and mitigating ARP spoofing attacks, as proposed in [13].

Hardware solution

Enthusiastic ARP assessment was applied in unambiguous changes to get additional security and confirmation of the relationship from ARP satirizing assaults. Its affirmations advancing of just supported ARP answers and requests. Ethernet change sees the cogency of the spread-out ARP bundles.

Manipulation of DNS

The DNS server employs a referenced ID scheme for URL resolution, which is integral to the client-server architecture. The DNS space and server names are dynamically organized into subordinate level domains. One of the most detrimental attacks, aimed at enhancing performance through cache poisoning, encompasses three main types: data packet sniffing during transmission, cache poisoning during celebratory events, and unauthorized DNS querying. By manipulating and controlling the local DNS, attackers coerce the target user into utilizing a fraudulent server to execute DNS spoofing. DNS manages the Time-to-Live (TTL) of domains and retrieves data from its cache. DNS spoofing attacks are executed through a denial-of-service approach. The attack involves two stages: first, the attacker injects a malicious DNS into the network, generating false data, and second, the attacker sends a fake DNS response before a legitimate one, thus intercepting the resolution process.

Detection of DNS spoofing

A straightforward method is provided for identifying such assaults:

MITM IN VANETS

MITM attacks, also known as Message Injection attacks, involve attackers attempting to modify the communication between legitimate entities, and their outcomes are particularly critical as such messages often contain sensitive information. These attacks are executed in two modes: an active mode and a passive mode, as depicted in Figure 3a.

Simulation Findings and Analysis

In this piece of the paper, the consequences of two varieties of man-in-the-middle attacks in VANET – message upset and message change – are showed up through framing.

Message Delay Attacks

After the man-in-the-middle attack, the nodes experience a 2-second delay, as depicted in the figure above. An appreciable increase in delay occurs when multiple malicious nodes are introduced into such networks. This is because relays ensure that messages reach their endpoints without delay, leading to a significant impact on network performance by such attackers. The interaction is directly proportional to the presence of malicious nodes; even a tenth of the nodes can introduce delays of up to 47%. As the percentage of malicious nodes reaches 60%, latency in these networks can rise to 80%. Figure 4b illustrates that communication may still occur despite attacks, albeit with a temporal delay. The measurement in the image below confirms that the message reached the endpoint, albeit with a particular delay. Continuing from the previous point, an increase in the number of malicious nodes leads to a



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noticeable rise in packet loss and delay. For example, if a network is infiltrated with approximately 40% malicious nodes, it results in approximately 20% packet loss.

Message Tamper Attacks

Taking into account the points discussed thus far, it becomes apparent that the existence of any compromised node within the network can impact not only the content or destination of the message but also various aspects of the data. In such scenarios, this paper specifically focuses on preserving the integrity of the message data. As depicted in Figure 5a, disruptions within the network, exemplified by a malicious node, have the potential to alter the overall message content. Additionally, the end-to-end delay in the network generally escalates in correlation with the inclusion of compromised nodes. Naturally, there is a decrease in CDR as the number of malicious nodes increases, as shown in Figure 5b. Additionally, the attack's path will influence the CDR. As depicted in Fig 5b, when a lesser portion of the network is malicious, the end user can choose to offload genuine messages to the recipient. This leads to a potential increase in CDR. The final segment of the study outlines the quantity of altered messages, sharing a similar nature with the preceding part of the research. Owing to the widespread presence of malicious nodes throughout the network, a considerable number of messages and their contents are compromised. Furthermore, malicious hubs are overwhelmed due to the high frequency of fabricated message contents. Figure 6 illustrates the severity of the compromised messages.

CONCLUSIONS

The aim of this paper is to examine various MITM attacks and provide a comprehensive overview of these assaults, along with defensive mechanisms based on PC impersonation practices. In addition to presenting different MITM defense strategies and their descriptions, the paper focuses on ensuring data integrity and security, as well as the smooth transmission of genuine data between endpoints, which are the primary objectives of the adversary. The latter part of the paper reviews various types of person-in-the-middle attacks and their corresponding defensive strategies. Currently, one of the most significant challenges lies in the fact that Man-in-the-Middle attacks are still facilitated by streaming data through a proxy. However, the evolution of the MITM technique has not been fully elucidated, thus laying the groundwork for subsequent research. Key distribution and elliptic curve cryptography are two examples of cryptographic techniques that can complement man-in-the-middle attacks. In future studies, it is imperative to expand our investigation to assess the impact of such attacks on various VANET infrastructures, particularly concerning node scalability.

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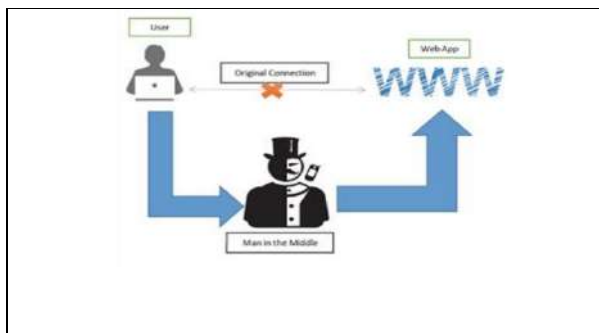


Fig. 1. Man in the Middle Attack

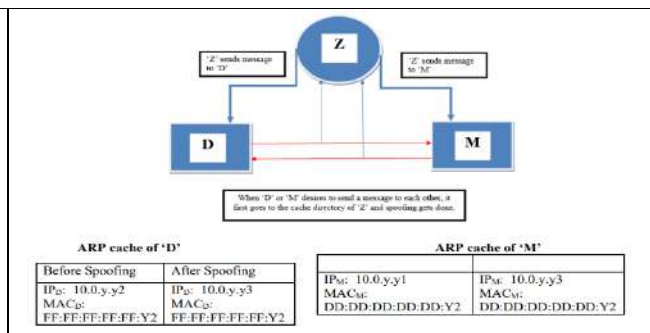


Fig. 2. Spoofing in between two users

Medium of Communication	Protocol	Concerns
Server Based Communication	ARP	Can't work for wireless communications.
Server Based/ Host Based	ARP, DHCP	Compatible for DoS. DHCP but has a single point of failure.
Host Based	ARP	Level of importance of each host is very difficult to decide.
Host Based	ARP	Works only with Linksys routers. Static IP not supported.
Cryptographic/ Host Based	UDP/ ARP	For UDP, authentication is a must need.
SYMMETRIC PRIVATE-KEY CRYPTOGRAPHY	DHCP	Legitimate hosts must register in advance, adds additional message flow, hard to manage for large number of hosts.
SYMMETRIC PRIVATE-KEY CRYPTOGRAPHY, RFC	DCHP, DHCP	The authors did not describe how the random value (the number, which used by the server and client to compute the session key) is determined.
Router Based	IP, ARP	Filtering-on-path method can't ensure a secure communication.
Router/ Host Based	IP, DHCP	This system is considered as the highest secured communication. But not so user friendly.

Fig. 3. Comparison of various methods for preventing

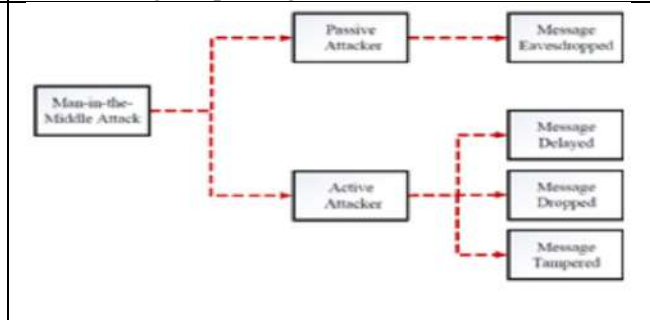


Fig. 4. MITIM in VANETS





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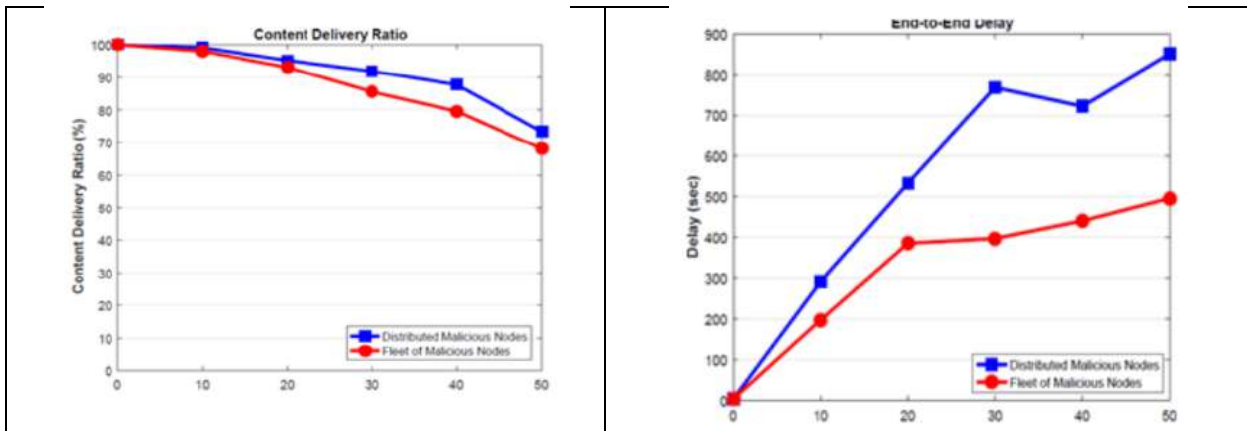


Fig. 5. Compromised Nodes

Fig. 6. Malicious nodes (%)

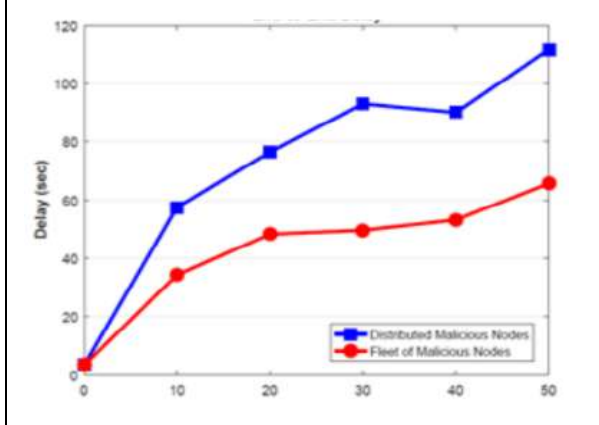


Fig. 7. End to End Delay

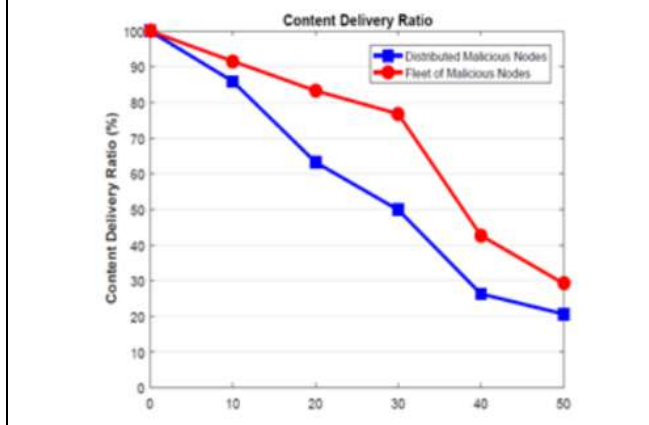


Fig. 8. CDR

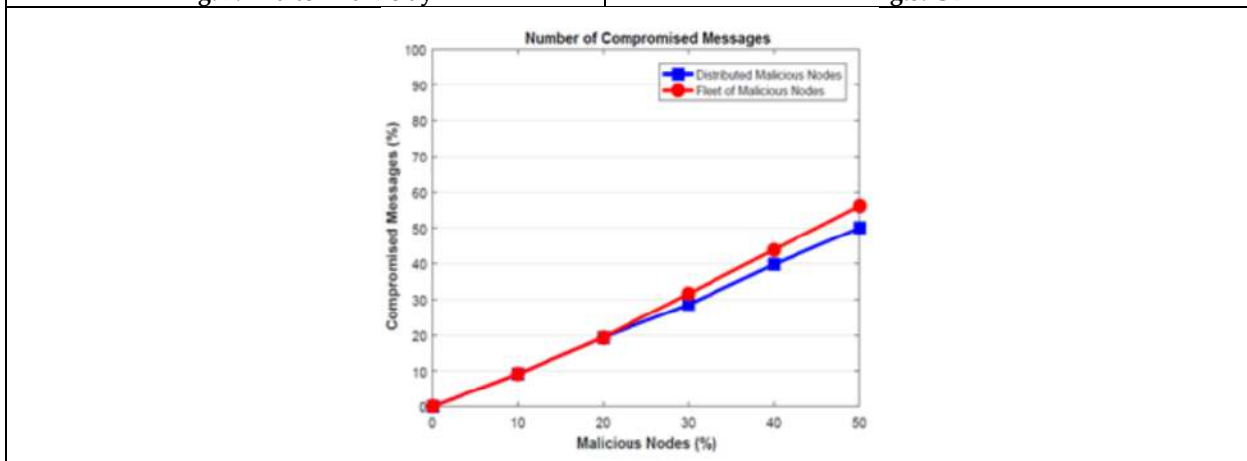


Fig. 9. No of Compromised message





Concept of Man, Health and Disease in Homoeopathy

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ABSTRACT

Man has been since time immemorial baffled by disease and suffering. From God's Curses to blatant superstition, we have been searching for the cause of disease. With the advancement of science, we have the advantage of identifying pathogens and reactive agents. But these pathogens and agents have existed with us for a long time. After a dinner out, why do I suffer from gastritis and not my friend, even though we ate the same thing, is the eternal question. "Why me." Here we have been trying to answer this through homoeopathy.

Keywords: we have been searching for the cause of disease. With the advancement of science, we have the advantage of identifying pathogens and reactive agents.

INTRODUCTION

Nature is dynamic. Every part of it vibrates like a never-ending rhythm of the tuning fork. But it always follows a set pattern. It follows the regularity and periodicity of the higher order. What is reality? Albert Einstein says, 'Reality is merely an illusion.' It changes according to the person experiencing it. It is the exact reflection of our deep inner pattern – our personality. What is reality for one person may be an imagination for the other. "Absolute reality" has no basis in individual experiences. Each person experiences reality in his/her unique way. Werner Heisenberg says, 'What we observe is not the nature itself, but the nature exposed to our methods of questioning.' Therefore, what people narrate is not reality but their own experience of reality. Our personalities perceive and react to everything including different situations and diseases, in a unique way and with varying degrees of intensity as compared to other personalities. B K sarkar in his organon says, we do not observe life but only living beings. We can study living organisms' properties and differentiate them from other non-living entities. Dr. Hahnemann says as practical physicians we are more concerned with the scientific aspect of life and this confusion of categories is the cause of



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failure. The chief source of complexity in observing life phenomena is that life though dynamic expresses itself through the material body. The result is that physio-chemical phenomena and vital phenomena exist together. Hahnemann observed one fundamental difference between a living and a non-living body. The living body is endowed with sensations, functions, and the power of self-preservation. In health, man is in a state of ease of comfort with regards to sensations felt by him and functions of his body. He feels neither the existence of his organs nor the tasks carried out by them. As soon as he feels the existence of his internal organ or its workings in any way, he becomes diseased. That brings us to the question, who is man? Einstein says, "A human being is a part of the whole, called by us the universe, a part limited by time and space. He experiences himself, his thoughts, and feelings, as something separate from the rest, a kind of optical delusion."

Dr. Vishpala Parthasarathy emphasises that our body is a whole unit. We may give different names to diseases affecting various organs or parts of the body. It is just the different phases of the disease moving from periphery to centre. Every expression of disease is a chain of cause and effect with a beginning, growth, and end. When we understand the disease in relation to the human body's immune response, we will be able to perceive and realise the benefits of homoeopathy. Homoeopathy since the beginning advocates the concept of unity of mind and body. This unity can only keep the man healthy and functional. Homoeopathy is firmly rooted in the idea that no two individuals are ever likely to come up with exactly similar descriptions of their symptoms. S M Gunavante says the vital force has its sway over the whole body, all organs, and tissues of the patient. It is involved in resistance to diseases wherever they may occur. Therefore, homoeopathic medicines aim to restore the deranged vital force to its full power. No organ can become diseased without a preceding disturbance of the vital force. And, therefore it is a mistake to treat a part as if it stood alone.

This dynamization cannot exist without a governing principle which can be termed as a Vital force. Dr. Herbert Roberts the stalwart of Homoeopathy writes, "When two parent cells are united, the vital energy, is already present. It has the power to develop the cells. This vital energy is the cause, the living organism is capable of physical action and mental capacity." The influence of this vital force is so delicately adjusted and intimately connected with every part, that seemingly distant organs or unrelated symptoms show the effects of disturbance. Susceptibility is the inherent capacity of matter of life to receive impressions. It also has the power of a living organism to react to stimuli. In living beings, susceptibility varies in response to their perception of reality. Any change in the normal susceptibility will interfere with the capacity of the predetermined response. This interference will be reflected in a chain response. This in turn leads to the loss of balance of health. Health is a balanced condition of the living organism in which the (integral, harmonious performance of) vital force tends to preserve the organism and help in the normal development of the individual. Whereas, disease is an abnormal process, a changed condition of life, which is inimical to the true development of the individual and leads to organic dissolution.

Agents, material or immaterial, which modify health or cause disease, act solely by their substantial existence and the co-existence of the vital substance which reacts in the living organism to every impression made within or without. Power resides at the centre. The phenomena of life, as manifested in growth, nutrition, repair, secretion, excretion, self-recognition, self-preservation, and reproduction all take their direction from the centre. Resistance to morbid agents is from the centre where life reigns. Vital resistance is the defensive action of the living to the obnoxious elements. Metaphorically speaking, disease is resistance. It is unveiled through symptoms. It is a battle, a struggle, a costly and painful resistance to the invader. We must differentiate between the cause and the effect. We must not let the phenomena which we perceive with our organs of sensation bind us to the existence of the invisible poser which produces them. Functional or dynamic change always precedes tissue changes. Internal changes take place before the external signs.





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CONCLUSION

The mere removal of the tangible products of disease does not always lead to a cure. The cure is often obtained by internal administration of the remedy, with due regard to proper auxiliary, psychical, hygienic, and mechanical treatment.

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Hybrid Machine Learning Models to Improve Road Traffic Accident Prediction Accuracy: A Whole-System Approach

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ABSTRACT

In the realm of road safety, accurately predicting traffic accidents is pivotal for implementing proactive measures and reducing accident rates. This study presents a comprehensive approach to enhancing prediction accuracy by employing a hybrid machine learning model, combining Random Forest (RF) and Support Vector Machine (SVM) techniques. The dataset, collected from Kaggle, encompasses road traffic accidents from 2017 to 2020, consisting of 32 features and 12,316 accident occurrences. Following data preprocessing, including Min-Max normalization, the hybrid RF-SVM model is implemented to leverage the strengths of both ensemble learning and margin-based classifiers. The Random Forest component is utilized for feature selection and dimensionality reduction, efficiently handling large datasets and identifying the most significant features contributing to accidents. This step reduces the model's complexity and enhances its interpretability. Subsequently, the SVM component performs the classification task, optimizing decision boundaries with a focused set of features. The SVM's ability to handle both linear and non-linear relationships, coupled with kernel tricks, ensures robust separation of accident-prone and non-accident-prone instances. Comparative analysis with other hybrid models, such as Conv-LSTM, CNN-LSTM, and CNN-GRU, demonstrates the superior performance of the RF-SVM model. The proposed model is implemented in Python software that achieves an impressive accuracy of 99.13%. These metrics underscore the model's capability to provide reliable predictions and effectively balance precision and recall. The insights gained from the feature selection process inform policymakers about critical factors contributing to accidents, guiding targeted interventions for road safety improvements. This study's findings highlight the potential of hybrid machine learning models in advancing the predictive analytics of road traffic accidents, paving the way for smarter, data-driven road safety strategies.



**Girija and Divya****Keywords:** Support Vector Machine, Random Forest, road traffic, accident severity prediction, Machine Learning**INTRODUCTION**

Across the Indian subcontinent, there is a general concern with car crashes. In the US, car crashes claimed the lives of almost 151,000 individuals in 2019. About three and five percentage points of GDP was lost each year as a result of traffic accidents. India is home to only 1% of the world's autos, yet in 2013 it accounted for around 6% of all traffic accidents. Nearly 70% of the incidents affected younger Indians[1][2]. Traffic research predict that there will be a rise in the amount of car accident-related deaths and injuries. Modern methods are currently being used for traffic administration and preparation due to its significance. Vehicle crashes will decrease as a result of laws and actions that are predicated on the idea that there are traffic hazards[3]. The investigators presented a computer vision-based approach for predicting car crashes[4]. By monitoring roadside camera recordings, they were enabled to understand certain circumstances with an accuracy of 85%. Researchers who find value in the underlying causes of crashes on roads have performed more study in recent years[5]. Researchers studied driver behavior and strategy throughout the whole variable lane structure in order to pinpoint potentially hazardous driving behaviors. A high roadway slope puts both vehicles and pedestrians at serious risk, based to research looking into the relationship among pavement conditions and auto accidents. Furthermore, the threats presented by climate change and the changing demography of visitors have never been the subject of any previous investigation. But most of these studies have just examined one aspect of the environment whether it is motorists, tourists, highways, or the surroundings overall in connection to injuries[6]. In order to guarantee the security of participants at the database mining equipment event, a range of data mining strategies are employed by college pupils[7]. The investigation of the causative elements that lead to visitor damage frequently involves the use of organizational data mining.

Strict communication standards are used to expose the hidden networks throughout the risk data[8]. Constructing the foundations in such a way that the users can live up to the value and standards of the underpinnings with a dual standard of trust and encouragement can draw them in[9]. The alarmingly high daily toll of people died in traffic accidents more than 3,000 means that "road security represents an enormous public health issue in today's society." Road accidents also cause damage to the world economy. The expenses incurred by emerging nations due to this[10][11]. The road communication unit is vital for conducting study on the recognition of essential elements for an improved comprehension of the order of events and the usage of connected data in important target positions. There are several regionally accessible mining strategies available for a small amount expenditure when it involves transmitting Brodbingnagian data. Only one Asian nation's officials had documentation of the collision. The method used to aggregate, compile, and record data about accidents has an extensive list of enhancements that the channel, which covers incidents of accidents exclusively, would like to see created. At present, analysts rely solely on the simplest details and report failure when attempting to draw inferences from it; data mining tools are widely available. Scholars utilise an extensive range of information mining methodologies. Data mining has been used to extract predictable details from large knowledge sets, and the results of the data summary are often displayed in an intuitive manner. Techniques for analysing data help identify the most significant or enduring patterns. The key contributions of the article is,

- This study introduces a novel hybrid ML model that combines RF and SVM techniques, effectively leveraging the strengths of both ensemble learning and margin-based classifiers for improved road traffic accident prediction accuracy.
- By utilizing the RF component for feature selection and dimensionality reduction, the study efficiently handles large datasets and identifies the most significant features contributing to accidents, reducing model complexity and enhancing interpretability.
- The insights gained from the model's feature selection process provide valuable information for policymakers about critical factors contributing to road traffic accidents, guiding targeted interventions and proactive measures to improve road safety and reduce accident rates.



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- The organization of the paper is, section II and III gives the related works and methodology respectively. Section IV gives the results and the article is concluded in section V.

RELATED WORKS

In everyday circumstances, traffic accidents typically result in significant loss of life and significant financial damages[12]. Predicting crashes in an efficient and precise way can significantly improve safety for everyone and lower financial costs. Due to the complicated causation of crashes, which involves a number of variables such as time dynamic connections, spatial correlations, and external impacts in road-relevant diverse information, it is difficult to anticipate crashes while driving. This research suggests a unique Deep Spatio-Temporal Graph Convolutional Network, or DSTGCN, to anticipate traffic accidents in order to address the aforementioned problems. The suggested model consists of three parts: the spatial learning layer, that learns spatial correlations by performing graph convolutional calculations on spatial data. The following part is the spatio-temporal training layer, that captures the dynamic alterations across the spatial and temporal viewpoint by using conventional and graph convolutions. The incorporation layer, that makes up the third part, seeks to provide coherent and semantic illustrations for outside data. We gather extensive actual-world information, such as accident reports, citywide automobile speeds, roadways, temperatures, and Point-of-Interest payments, in order to assess the suggested model. Experiments on actual data show that DSTGCN works better than modern facilities and traditional approaches. In order to increase protection in smart communities, rear-end collision prevention is receiving more and more attention[13]. As one of the primary causes of crashes, rear-end crashes require the development of effective warning techniques immediately. The goal of the current study is to forecast collisions. It is suggested to use learning-based approaches to tackle this challenging problem, which goes beyond the scope of conventional approaches. Back-propagation learning techniques, nevertheless, are having difficulties because of certain restrictions on finding features and prediction accuracy. In this study, we introduced a novel DL-based RCPM that establishes a CNN model.

To address the issue of disparities in class, RCPM expands and smoothes the dataset using evolutionary theory. We utilize the prepared dataset as the source of data for the model, splitting it into training and testing sets. The results of the study demonstrate that RCPM significantly enhances rear-end collision prediction accuracy. To lessen its negative impacts, crash detection is crucial for giving the public and roadway management centers current data[14]. For the purpose of preventing secondary collisions and protecting road traffic, crash risk forecasting is essential. In an effort to support traffic management of incidents, academics have spent many years investigating various methods for the accurate and timely identification of collisions. Real-time traffic data is widely available for usage because to recent developments in data gathering systems. The information may be used by big data architecture and ML to deliver suitable answers for the highway traffic safety systems. This research investigates whether DL models can be used to forecast crash risk and identify crash incidence. For this investigation, data on volume, speed, and sensor saturation were gathered from wayside radar detectors along Highway 235 in Des Moines, Iowa. The findings demonstrate that, in comparison to state-of-the-art shallow models, a deep model performs similarly well in accident predictions and better in crash detection. Furthermore, an analysis of sensitivity was carried out to estimate the accident danger based on data collected one, five, and ten minutes before the collision happened. Ten minutes before an accident, it was found that it was difficult to anticipate the possibility of a traffic circumstance. In order to create models that forecast the extent of accident damages in the event of a motorbike incident, this research employs categorization techniques[15]. By contrasting their outcomes, the researchers assessed the predictive capacity of the MLP, rule induction (PART), and classification and regression trees (SimpleCart) models for determining the seriousness of motorbike crashes. The Building and Road Research Institute in Ghana's National Road Traffic Collision Dataset provided the motorbike collision data set used to achieve this goal. Four classifications of harm severity were applied to the data established: deterioration, hospitalized, wounded, and death. In addition to enabling the direct comparison and ranking of the data mining models, the information gathered from this collection of data will make it possible to identify the factors that have a substantial impact on the severity of motorbike crashes. Utilizing a 10-fold cross-validation strategy, the Simple Cart model beat the PART models (73.45%) and the





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model developed by MLP (72.16%) out of the investigated classification methods, according to the findings. The Simple Cart model had a mean accuracy of 73.81%. The findings showgoer that the site type, settlements type, accident time, accident type, and collision companion were the most important variables linked to the degree of injuries sustained in a motorbike incident.

Proposed RF-SVM Framework

The methodology of the article includes min-max normalization for preprocessing and hybrid RF-SVM for accident prediction. It is depicted in Fig 1.

Data Collection

The road traffic accident dataset is collected from Kaggle [16]. The written accounts of traffic accidents from 2017 to 20 are the source of this data collection. After all sensitive data was removed throughout data encoding, the final product comprises 32 features and 12316 accident occurrences. After that, it is preprocessed and analyzed utilizing various ML approaches to classification in order to determine the primary reasons of the event. RTA Information Base. The dataset in csv format is unprocessed and unclean. The preprocessed dataset is called csv.

Preprocessing using Min-Max Normalization

Preprocessing the road site visitors twist of fate dataset is a important step to make sure the effectiveness of the subsequent system learning models. One not unusual and effective preprocessing approach is Min-Max Normalization, which scales the functions of the dataset to a particular range, usually [0, 1]. This technique transforms each function with the aid of subtracting the minimal value of that characteristic and then dividing via the range of the characteristic values (most fee minus minimum fee). Min-Max Normalization ensures that large-scale features do now not dominate the studying system, thereby enhancing the performance and convergence speed of many gadget learning algorithms.

$$Y_{norm} = \frac{y - y_{minimum}}{y_{maximum} - z} \quad \text{③③③}$$

In the context of our avenue site visitors accident dataset, Min-Max Normalization helps in dealing with the various variety of values across exclusive functions. For example, numerical features like car velocity and time of day will have hugely one-of-a-kind scales, which would possibly skew the model if left unnormalized. After normalization, the dataset is ready for in addition evaluation and version schooling, making sure that each characteristic contributes similarly to the predictive modeling technique.

Employing RF-SVM for Road Traffic Accident Prediction

Employing a hybrid version like RF-SVM for road site visitors' accident prediction combines the strengths of both ensemble getting to know and margin-based totally classifiers, offering a strong approach to predictive modeling. The first section of this hybrid version involves using RF for function choice and dimensionality reduction. Random Forest, an ensemble learning method, operates by means of constructing multiple selection trees at some stage in schooling and outputting the mode of the training (class) of the individual timber. Random Forest's capability to handle lacking facts and keep accuracy without tremendous preprocessing makes it super preference for the preliminary segment of the hybrid version. By utilizing Random Forest for characteristic choice, we can slim down the most influential factors contributing to street traffic accidents from the significant list of features. This no longer only improves the efficiency of the version but additionally facilitates in expertise the important thing factors that want interest for twist of fate prevention. Moreover, the ensemble nature of Random Forest offers robustness against overfitting, making sure that the selected features generalize well on unseen facts. The second phase of the RF-SVM model entails employing SVM for the real type or prediction mission. SVM is renowned for its effectiveness in excessive-dimensional areas and is mainly suitable for class tasks. After the dimensionality discount through Random Forest, SVM takes over with a targeted set of functions, optimizing the selection barriers between classes of street visitors injuries. The middle concept of SVM is to locate the hyperplane that pleasant separates the specific classes in the feature area. This characteristic of SVM makes it incredibly effective in distinguishing between coincidence-susceptible and non-twist of fate-prone times, thereby improving predictive accuracy. In practice, the





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RF-SVM hybrid model is skilled in distinct stages. Initially, the Random Forest model is educated on the dataset to determine the importance rankings for every function. Features with the very best significance scores are then selected for the second one stage, in which the SVM model is trained the use of this refined characteristic set. This staged approach no longer simplest streamlines the computational process but also enhances the interpretability of the version by means of focusing on the most impactful features. During the training segment, the model parameters for both Random Forest and SVM are tuned the use of move-validation strategies to avoid overfitting and make certain top of the line overall performance on the validation statistics. The utility of RF-SVM in street traffic coincidence prediction can notably beautify the accuracy and performance of predictive methods. As a result, it presents a powerful tool for predicting road traffic accidents, allowing authorities to enforce proactive measures for coincidence prevention and improve ordinary avenue safety. The insights gained from the function choice process can also manual policymakers in focusing their efforts at the maximum important elements contributing to street site visitors' injuries, thereby making statistics-pushed selections for public protection enhancements.

RESULTS AND DISCUSSION

The performance assessment of the suggested model, which is implemented in Python, is included in the results section.

Accident Severity

The Fig 2 offers a contrast of traffic density against accident severity, illustrating the count number of injuries labeled by means of their threat degree High Risk, Low Risk, and Moderate Risk across specific traffic densities (High, Low, and Moderate). In areas with excessive site visitors' density, there are 500 excessive-danger injuries and 2500 low-risk injuries, with no moderate-chance injuries recorded. For low site visitors' density, all 3500 injuries fall below the low-chance category, displaying no presence of excessive-threat or slight-hazard accidents. In mild visitors' density eventualities, 500 injuries are labeled as mild risk, at the same time as 3000 are considered low danger.

Accident Severity due to Road Structure

Fig 3 illustrates the connection among accident severity and road structure. It indicates that injuries going on curved roads or poorly maintained surfaces tend to bring about extra extreme results compared to the ones on nicely-maintained directly roads. The facts depicted inside the parent suggests that road structure plays a crucial function in coincidence severity, with complex or deteriorated avenue situations usually leading to higher damage stages and greater extreme crashes.

Performance Metrics

The Conv-LSTM model achieves high scores with 98.12% accuracy, 94.77% precision, 96.98% recall, and 92.83% F1-Score, indicating strong performance across all metrics. The CNN-LSTM model follows closely with an accuracy of 97.97%, but shows a notable drop in precision (89.55%) and recall (92.45%), resulting in a slightly lower F1-Score of 91.67%. The CNN-GRU model, while maintaining a respectable accuracy of 96.89%, demonstrates high precision (94.56%) and F1-Score (94.32%), but a slightly lower recall (92.77%). The proposed RF-SVM model outperforms all other models with an impressive accuracy of 99.13%, precision of 96.32%, recall of 97.13%, and F1-Score of 95.47%, highlighting its superior ability to accurately predict road traffic accidents and effectively balance precision and recall. The performance metrics comparison is given in Table I.

DISCUSSION

Achieving an accuracy of 99.13%, the RF-SVM version outperforms other hybrid models inclusive of Conv-LSTM, CNN-LSTM, and CNN-GRU. The high precision (96.32%), remember (97.13%), and F1-Score (97.47%) metrics further highlight the version's robustness and its potential to provide reliable predictions. The ability of the RF-SVM version



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to handle each linear and non-linear relationships within the data guarantees that it could accurately distinguish among coincidence-susceptible and non-twist of fate-susceptible times, imparting a complete and unique predictive tool. Furthermore, the feature selection process using Random Forest now not simplest improves the version's efficiency however additionally offers precious insights into the factors contributing to road visitors accidents. This manner diagnosed key features which might be most predictive of twist of fate occurrences, that may inform policymakers and visitors control authorities approximately important areas that need attention. For example, elements which includes avenue shape, traffic density, and environmental conditions had been highlighted as vast predictors. The superior overall performance of the RF-SVM version in comparison to different hybrid strategies underscores its capability for actual-global software in visitors management systems.

CONCLUSION AND FUTURE WORKS

Achieving an outstanding accuracy of 99.13%, alongside sturdy precision, bear in mind, and F1-Score metrics, the RF-SVM model surpasses different hybrid approaches together with Conv-LSTM, CNN-LSTM, and CNN-GRU. Future works may want to recognition on expanding the dataset to encompass extra latest data and a broader range of features, which include climate situations, actual-time visitors updates, and driving force behavior metrics, to similarly decorate the version's predictive electricity. Integrating advanced ML of techniques like DL and reinforcement learning can also be explored to capture extra complicated patterns and interactions inside the information. Additionally, actual-time implementation of the model in visitors control structures and its integration with smart city infrastructure should offer dynamic, real-time predictions and alerts, thereby considerably improving avenue protection.

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Table 1: Performance Metrics Comparison

Methods	Performance Metrics			
	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)
Conv-LSTM [17]	98.12	94.77	96.98	92.83
CNN –LSTM [18]	97.97	89.55	92.45	91.67
CNN-GRU [19]	96.89	94.56	92.77	94.32
Proposed RF-SVM	99.13	96.32	97.13	95.47

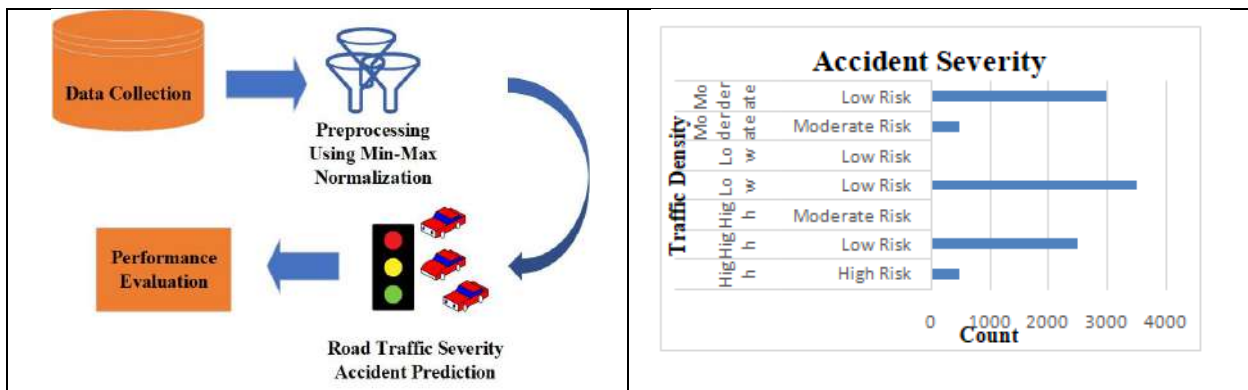


Fig. 1. Proposed Methodology

Fig. 2. Accident Severity

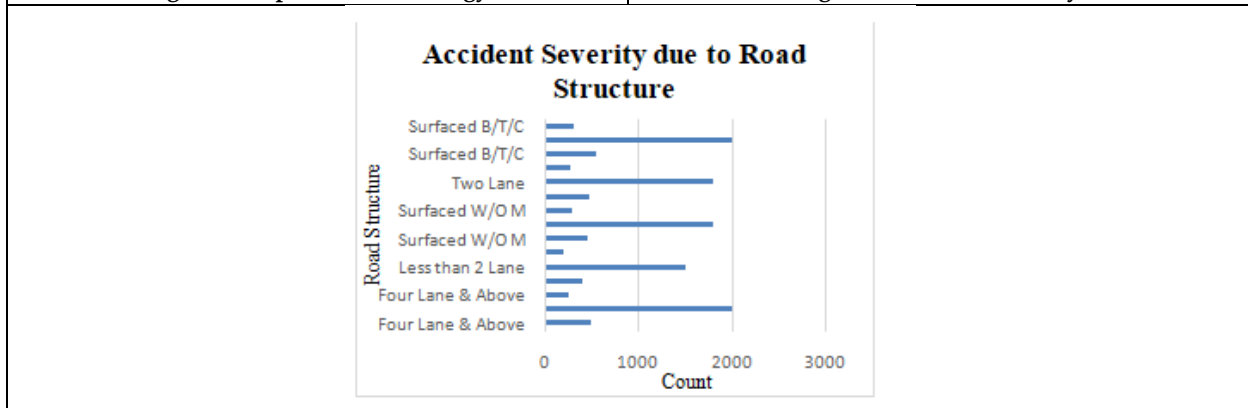


Fig. 3. Accident Severity due to Road Structure





Automated Rail Track Inspection Trolley with IoT

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ABSTRACT

Railway Transportation in India is considered to be the best choice of transportation for passengers as well as goods. Every year, more than 1.2 billion tonnes of freight are being moved by Railway. Railway transportation needs regular examinations and quick servicing for the sake of national security. Conventional manual screenings are time consuming and costly. Individual skill and effectiveness are the need of the time of survey to find out errors. As a result, Internet of Things (IoT) arises as a solution, which uses technology as well as automation. IoT and automation help the machinery, which are installed on railway tracks and areas which find difficult to reach places and can be handled through the control rooms. As a result, the outcome is suggested to be an automated robot. The robot helps in visually inspecting the outreach areas. The technology has advancement of enabling the process to get images onsite and perform analysis. The facility of cloud services can be an advantage for the images and photographs taken of the broken railway tracks. The method suggested can relate the Machine Learning technique to pictures received from the rails. It easily identifies them as regular or normal or threat/dangerous. Such places are identified. Some specialized operator with a small number of sites perform some more tests and examinations.

Keywords: Railway track, Sensor, fault detection, IoT, Track crack





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INTRODUCTION

Railway Transport is the mode of transport, refers to moving passengers or goods with the help of train on a rail or a railroad. Rail transport plays a vital role in our day-to-day life. These are locomotives with high cost. In the last ten years, there has been remarkable growth in the infrastructure of the railway system, especially in developing countries. One challenge that arises is the ability to sufficiently power monitoring equipment in remote location. It's an in-service vehicle with sensors[1]. The tracks are detected and relayed using a global positioning system. RAIL transport is the most efficient, cost-effective and convenient means of transport. It has lower fuel costs. It is capable of transporting large loads, environmentally friendly and, most importantly, is also very reliable, as it is not hindered by weather in the same way as road and air transport do. Rail transport has therefore become the backbone of every emerging economy. Continuous and smooth operation of rail transport depend on effective management of the rail infrastructure as well as railway condition monitoring. It detects the deterioration and deformation of rail tracks[2]. The factors responsible for it are the load of rail vehicle on rail tracks, terrain where rail track is deployed, materials used in rail track construction and environmental conditions. The prime objective of monitoring the railway condition is to detect the track deterioration before it causes failure and prevents rail operations. Most important rail transport infrastructure is the purpose of railway condition monitoring [4]. The biggest Rail Networks has been with India in the World. The manual method and crack detection on lines is a time consuming and labour intensive procedure. The safe operation of railway transportation is always threatened by postponed inspections and problem findings. Railway in India is the most widely used transport system. Government of India had taken over the entire railway system in the country in 1950[5]. It is one of the largest transportation and logistics network of the world. Approximate 12,000 trains are to carry over 23 million passengers per day, which connect about 8,000 stations spread across the subcontinent. Railways is key responsible in growing and spreading the size of markets. The technology used in railways need to be upgraded[6]. The incidence of railway accidents in our country is greater as compared to other countries. According to the Railways, out of 100 accidents, at least seven takes place due to fractured tracks. For example on March 30, 2017 some Crack found in tracks led to derailment. A crack in the tracks prima facie caused the derailment of eight coaches of Mahakaushal Express near Mahoba station in Uttar Pradesh. Eight bogies of the Jabalpur-Nizamuddin Mahakaushal Express had derailed, as a result of which 52 passengers got injured. 400 metres of track got damaged and disrupted rail traffic on the route with services of 14 trains disrupted[7].

Literature Background and Proposed Method

The faults found in rail tracks give rise to the evolution of Crack Detection System in rail track. A system is designed to detect the flaws in the rail track with help of ultrasound testing method. After the crack is detected, the respective coordinates are found and they are sent to the nearest station. GPS and GSM Modules are responsible of performing recording and sending of coordinates to respective station. The most effective technique for detecting cracks is done by Ultrasonic technique[6][8]. It helps in detecting minor cracks and calculates the growth rate. When ultrasound wave signal propagates from one medium to another distinct medium, a certain proportion of the signal energy propagates over to the other medium. The remaining energy reflect back. After the reflected signals, time difference of arrival (TDOA) is measured. By using this time delay, the thickness and the flaws in the material are calculated[9]. The various rail flaws along with the inspection and maintenance methods are explained well. As a result of which algorithm is proposed, and algorithm makes use of sensors. These sensors help in detecting cracks and breakages in the railway tracks. Along with this it also proposes the technique to update train engine on regular basis and acknowledge the track's status and exact location of the track breakage. Predictive maintenance, issue detection, and eventually reducing the probability of train accidents are the major reasons for checking railway lines[10]. Train tracks must be inspected often. The manual examination of millions of track yards is labour intensive, time exhausting and prone for mistake. For which it is always preferred for Automatic track fault or crack identification along with monitoring[4][7]. A number of automatic solutions are generated for performing the task and increase its efficiency. In order to check rail lines, NDE methods are applied. Material group need the help of Computer vision, guided, and electromagnetic categories. For this, technologies like IoT and acoustic based methods are utilised. Intelligent Track Cleaning Robot can also be employed[2]. It is used to develop an efficient and economic way of



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designing product for cleaning the tracks. The proposed idea of automatic railway track cleaning system comprises an automatic vehicle that goes on land and track. It consists of a four wheel running robot with a suction unit, cleaning unit, automatic displacement unit, an intelligent control system, an intelligent train sensing unit, and power unit. The entire device is controlled by an onboard PIC microcontroller and the sensor networks on railway track. Guided wave system is another method to employ[11]. Here ultrasonic NDT was carried out with the DIO 572 equipment, which included measurement data processing. The device duplicated the shape of the rails during an ultrasonic test. The personal computer and the specialized program DIO 2000 were used to assess the measurement. A quantitative detection technique for accomplishing a visual assessment of crack is proposed[12]. The signal was also divided into various intrinsic mode functions (IMF) using VMD. The correlation variables along with SNR metrics were used to choose the most effective IMF element. Ultimately, employing ultrasonic propagation images and properties of signals are employed for generating wave momentum[13]. IoT based system: For employing an IoT based system, A self driving robot is employed which is powered by microcontroller and sensors. GPS module tracks help in the precise detective position and sends SMS notification[14]. The proposed system test the location of each clip on every single joint bar and alert the trains if any bolt went loose. A robotic technique prototype presented its ability to identify rail side flaws. The model used ultrasonic input from sensors combining image processing and deep learning techniques[14][15], to identify faults. Each robot was powered locally by the Raspberry Pi 3, a microcontroller, which sent real-time information to an ethernet server. To detect abnormalities, 4 ultrasonic sensors were put overhead and on both ends of an elevated train surface. An investigation on an automated defect tracking module integrated into an automated robot that uses several sensors[16]. The layer containing an infrared sensor, a restriction shift, and ultrasonic sensors that were all driven by an LPC 1768 ARM microprocessor. If a defect was identified, the GSM module sent the position and kind of fault to the inspection room[17].

An ultrasonic metal detection sensor was employed in the investigation to more precisely locate fractures. Encoding systems and radio frequency broadcasters were used for crack detection, with an ongoing supply of electricity between the encoding devices indicating fault-free tracks [18]. RF signals would be produced by the transmitter for so long as the electrical supply was steady [19]. The flow of current might be disrupted if there was a break in the track. This stops RF signal production, which prevents the locomotive's receiver from receiving a signal, causing train to stop[2][20]. A TRV(Track Recording Vehicle) is used for rail track problem diagnostics. According to site-specific testing, the system is more efficient than conventional method. The authors put forth a novel system of automation built on robot the localization over an interval of 3-6 inch[21]. To identify possible flaws, the system used machine learning and adapted it to the photographs it got from the tracks. A cost effective, less power required, wireless, and real-time IoT based sensing system has been developed in addition to a customized TRV replacing the manual production of features with an automated process for monitoring the rail condition and find out the damage[7][21]. It depends on the unique design of the TRV in comparison to the traditional trolley based TRV, which was to detect minor drop in vibrations which plays a vital role in the early detection of track damage.

The TRV is designed with an objective to make it portable and easily operable. The IoT based sensing system on TRV uses the Axle Based Acceleration (ABA) technique and is equipped with an inertial measurement unit (IMU) for the precise extraction of instantaneous irregular amplitudes of the acceleration signals in all three axes, to identifies the faults of the track and determines its severity[22]. The accelerometer data of the track dynamics are measured and transmitted using Node MCU to an online cloud network service in realtime through which the irregularity of the track is detected. Proposed design of the TRV can determine the damage to the tracks with impactful measurement accuracy. A new method for monitoring the irregularities in railway tracks by updating the status of the tracks in the cloud can also be explored. The IoT based Railway Track Monitoring System (IoT-RMS) is a proposed method to monitor the health of the railway track. The system identifies any kind of abnormality in the tracks at an early stage. These abnormalities are rectified before they develop for smoother transportation[14][23]. The microelectro mechanical system (MEMS) accelerometers are placed in the axle box for measuring the signal. It becomes hard to find the exact location of abnormalities when the global positioning system (GPS) falters due to signalling issues[15]. So a new hybrid method is proposed for locating irregularities on a track. It also can be occurred in absence of a GPS signal. Preprocessing of the GPS signal is carried out effectively, as the sensors used in IoT-RMS are good in



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functioning in a high noise environment[23]. The IoT-RMS updates the location of the abnormality in the cloud and shares it with other trains that will be passing through that location. As a result, the drivers of trains respond accordingly and avoid derailment. This seems to be a best approach of detection with the proposed system. An experimental setup has been developed for a study of the performances for four different abnormal cases, and the result shows the effectiveness of the proposed system.

Applications of proposed system: Followings are the applications for which a railway track crack detecting system.

1. Automatic Crack Testing- The process of finding a structure crack with any processing method is known as rail crack detection. Two techniques can be employed to identify cracks. The recommended approach sequentially makes use of radiometric, geometric, and contextual data[2][3]. The battery provides electricity to the vehicle. The rail track crack can be traced using the optical sensor.
2. Wireless Access- Wireless Application Protocol (WAP) is a networking standard utilized for transmitting data across numerous mobile networks. WAP enables quicker connectivity between dynamic wireless items with the Internet while also improving cellular standards compatibility[5]. WAP is a technology norm for obtaining data via a portable connection. A WAP browser is a web browser that utilizes the protocols for mobile devices like mobile phones. Despite being a novel technology, WAP makes use of Internet-related ideas.
3. Applications for detecting damage to railway track- In order to monitor and identify track damage, a neural network-based technique is utilized. Train crashes happen frequently by track damages[19]. The results of the experiments demonstrate the excellent precision and suitability of this neural network based measuring system for online track damage detection and monitoring applications.
4. The following techniques are used to find railway flaws: The method with the most use is ultrasound. Eddy current examinations are excellent for detecting surface and close-to-surface defects[25]. For thorough hand checks, employ magnetic particle inspection. The gap on the rail line is identified by an ultrasonic sensor by avoiding getting the sound of railway such that if the sound is heard, no fracture is found on the track.

CONCLUSION AND FUTURE SCOPE

The present approaches are based on the research, require time as well as cost. The proposed approach addresses these problems by significantly improving the method of rail track crack identification. It involves the most economical option available for improving the efficiency of the nation's largest transportation means including lowering accident rates. It may be quite possible to avoid a waste of resources and precious lives of people with the techniques employed. In addition to it, it eliminates expenditure and time on identifying cracks. It is highly essential being responsible citizen of our nation to take care of our largest Transportation System and adopt newest technologies.

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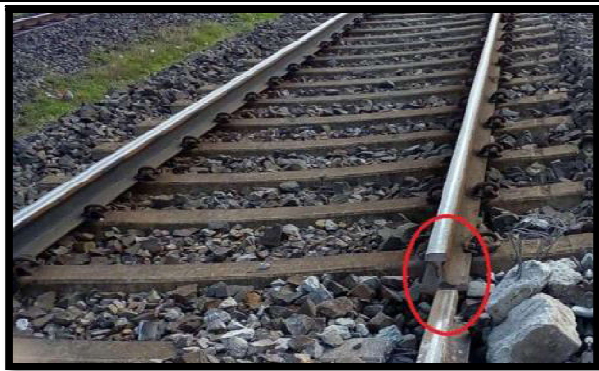


Fig.1-Crack image on Railway Track [4]



Fig.2-Push Trolley [4][26]

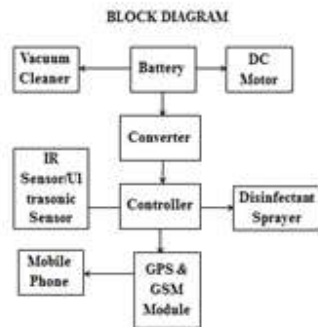


Fig.3-Block Diagram of IoT based System





Evaluation of Therapeutic Potential of *Cedrus deodara* Extract on Rotenone Induced Parkinson's *Drosophila* Model

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ABSTRACT

Parkinson's disease (PD) is a widely recognized neurological disorder characterized by involuntary movements, including tremors, stiffness and difficulties in coordination and balance. Its symptoms typically develop gradually and worsen over time, impacting walking and speech. *Drosophila melanogaster* has served as a model for various neurodegenerative conditions, including PD. In this study, we explored the impact of rotenone exposure on *Drosophila*, revealing noticeable neurodegenerative and behavioural effects within 14 days. Flies were subjected to rotenone induction by exposure to 0.197 µg/ml of rotenone through the media for 7 days and induced PD. Treating with high dose of *Cedrusdeodara* extract helps in improving olfactory function, locomotor disabilities and sexual behaviour compared to diseased group. Treated flies exhibited distinct locomotor impairments, which was alleviated by incorporating *Cedrusdeodara* into their diet. This suggests that pesticide exposure in *Drosophila* mirrors crucial aspects of PD, establishing a novel *in vivo* model for investigating the mechanisms behind dopaminergic neurodegeneration.

Keywords: Parkinson's disease, Neurodegenerative disease, *Drosophila melanogaster*, *Cedrusdeodara*, Rotenone.

INTRODUCTION

Parkinson's disease (PD) is a multifaceted neurological disorder characterized by a progressive deterioration of nerve cells in the basal ganglia region of the brain, which leads to a deficiency in the production of dopamine, a critical



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neurotransmitter. This depletion of dopamine results in a range of symptoms, including tremors, muscle stiffness, slow movement, and difficulties with balance and coordination. Additionally, individuals with PD may experience non-motor symptoms such as depression, sleep disturbances, and cognitive impairment. The exact cause of Parkinson's remains unknown, although research suggests a combination of genetic predisposition and environmental factors may play a role in its development. While age is a significant risk factor, with most cases emerging after the age of 60, individuals who develop the disease before the age of 50, often due to hereditary factors or specific genetic alterations[1]. The pathophysiology of PD involves the formation of abnormal protein clusters called Lewy bodies, primarily composed of alpha-synuclein, within brain cells. These clusters are associated with the degeneration of nerve cells responsible for dopamine production. Additionally, there is evidence of a gradual decline in dopamine levels associated with aging, which is accelerated in individuals with PD. Diagnosis of PD relies primarily on clinical evaluation by a neurologist, as there are currently no laboratory tests available for non-genetic cases. Treatment approaches aim to alleviate symptoms and may include medications to increase dopamine levels in the brain, surgical interventions such as deep brain stimulation, and various therapies including physical, occupational, and speech therapy. Animal models, such as the rotenone, MPTP, and 6-OHDA models, have been instrumental in studying the mechanisms of PD and testing potential therapeutic interventions[2–4]. These models replicate aspects of the disease by selectively targeting dopaminergic neurons or inducing neurotoxicity similar to that observed in PD[5]. Additionally, the *Drosophila melanogaster* model offers a valuable tool for understanding the genetic and molecular mechanisms underlying PD and exploring potential treatments[4,6]. The *Drosophila melanogaster*, or fruit fly, serves as a valuable alternative animal model for studying Parkinson's Disease (PD). With around 75% of human disease genes mirrored in *Drosophila*, this model has proven effective in unraveling the mechanisms underlying neurodegenerative diseases like PD. By expressing alpha-synuclein, researchers have elucidated connections between PD-related abnormalities such as dopaminergic cell degeneration, inclusion body formation, and impaired locomotion[6–8]. Notably, mutants with SPG7 in *Drosophila* exhibit progressive locomotion defects and heightened sensitivity to various stressors. The fruit fly's life cycle consists of four stages: embryo, larva, pupa, and adult, with a complete generation time of approximately 10 days and a maximum lifespan of 60 to 80 days depending on environmental conditions[8–10]. The present study aims to evaluate the therapeutic potential of *Cedrusdeodara* extract on rotenone induced Parkinson's disease *Drosophila melanogaster* model by assessing its effect on various behavioural parameters.

MATERIALS AND METHODS

Materials

Rotenone was procured from Sigma Aldrich.

Collection and Extraction of *Cedrusdeodara*

Cedrusdeodara plant bark collected from Rajaji national park, Uttarakhand and it is authenticated by the botanist from JSS college of arts, commerce & Science, Prof. Biligiri Ranga, HOD Department of Botany. The bark of *Cedrusdeodara* were cleaned to remove the adhered dust particles and then were sundried for 5 days. The dried aerial parts of *Cedrusdeodara* were crushed and weighed in grams. The dried powder was soaked overnight in hexane to remove color. Then filter and filtrate was collected and again dried for 2 days. The powdered sample was macerated or soaked for 7 days with a mixture of ethanol and water 7:3. The combined extract was purified and condensed at 65 degree Celsius in a rotating exhaust system[11].

Animals

Drosophila melanogaster: Maintenance and culturing of *Drosophila melanogaster*: OK Flies

Starting the Cycle

Seeding Embryos: The cycle initiates with 1.5grams of all the materials from preceding cycle comprising a mix of embryos and/or some early-stage larvae. In a plastic container this materials was placed which contains an active





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yeast mixture until the pupal phase was reached. Following the introduction of embryos in the container and larvae in this biological mixture, the container was covered with its lid to prevent the larvae from escaping.

Set up the plastic container.

Collect the plastic container and sterilize it; afterwards, cover the container with cotton plugs following the introduction of the flies. Proceed to prepare the fly food by stirring deionized water in a beaker, gradually adding propionic acid, phosphoric acid, dry yeast, and sucrose, initiating the fermentation process. Once the sucrose is dissolved, promptly pours the food evenly over cotton. Ensure thorough coverage and subsequently plastic container was closed the with the lid to prevent potential contamination by flies escaping within the laboratory. Re-suspend 1.5 grams of the harvested embryos previously, from the prior cycle in 5 ml of 70 percent of ethanol. Halve two filter papers, evenly distribute the biological mixture over the four pieces using a spatula or a wide-tipped transfer pipet cut if necessary. Place the filter papers atop the soaked cotton and securely closed the lid and finally, incubated the plastic container at room temperature at 24°C with humidity of 35% until the pupal stage.

Embryos to Flies: Continuing the Cycle.

This stage of the cycle begins on the first day the embryos was put in the plastic container and ends nine days later when the pupae hatch into adult flies. Throughout these 08 days, the primary task was monitoring to ensure the embryos was progress seamlessly through the subsequent stages till the *Drosophila* life cycle eclosion. If, during this period, larvae show signs of mortality and discoloration, it is essential to check that the foam plugs are not excessively tight and that sufficient ventilation was maintained. This interval also presents an opportune time for cleaning the fly population cage from the preceding cycle. Around 24 hours after the adult female deposits the embryos into the fly food, observe the embryos transitioning into 1st instar larvae. These resulting larvae will feed on the fly food prepared in step 1 for 4 days, undergoing growth and molting twice to reach the 2nd and 3rd instar larvae stages. On the fourth day of the setup, witness the larvae entering the pupal stage, where they will remain for an additional 4 days. It's important to note that during this phase, the pupae will cover the entire cotton surface inside the plastic container. Before the first flies emerge during the pupal phase, open the plastic container, transfer the plastic film containing the cotton with all the pupae onto the lab soaker paper within the cleaned population cage, secure it with a double knot, and cleaned the plastic container and lid for the next cycle. Be sure to discard and destroy pupae attached to the lid via autoclaving or freezing before eclosion. Following the 4-day pupal stage, the initial flies will emerge from the pupae, with all flies expected to eclose within 24-48 hours. During this phase, it is crucial to provide them with food to create the optimal environment for reproduction.

End of the Cycle

Harvesting Embryos: Optimal fly fertility occurs between 3 to 5 days after eclosion, making this period ideal for harvesting to achieve the highest embryo yield. Once the desired collections are finished, the cycle concludes. Observed the embryos, appearing as small white dots, indicating that the eggs was ready to be collected. For regular upkeep of the fly cage, a recommended collection time is every 2 days, resulting in a harvest mainly comprising embryos and a few 1st instar larvae. Refer to representative results for typical yields of harvested embryos at various collection time points[12, 13].

Culturing *Drosophila* in labs

Bottles serve to sustain a sizable population, while culturing vials are employed for smaller populations and crossbreeding purposes. Typically, glass bottles are the preferred choice, although autoclaved plastic bottles can also be effective. Additionally, the small vials come in various sizes, ranging from 96 mm by 25 mm to larger dimensions. Plugs, which can be either cotton or foam, are used to cover the bottles, with a preference for cotton plugs.

Media

The preparation of media involves two main methods: cooking the media or opting for ready-made and dehydrated media. The latter was the preferred choice due to its convenience, eliminating the need for cooking and offering a quicker and easier process. However, rehydration is necessary when using ready-made media. To ensure a thorough





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rehydration and culture process, follow the provided procedure. Begin by adding $\frac{1}{5}$ to $\frac{2}{5}$ volume of dry media to the bottle or vial, followed by the addition of water to completely saturate the media. Allow the vial to rest briefly, adding water until it appears fully hydrated, with a shiny surface and no gaps. Let the media warm to room temperature, ideally around 25 °C with 60% humidity for optimal fly growth. After rehydration, sprinkle several yeast grains on the media surface, and transfer the flies into the vial or bottle, sealing it. To maintain the culture, it is essential to transfer the flies to different clean vials or bottles[10].

Acute toxicity Study for Calculation of LD50 of *Cedrus Deodoura* extract

Three doses of CD extract, specifically 0.2mg, 0.4mg, and 0.8mg, were introduced into three separate vials containing culture media. The media was sustained for a duration of 3 days, during which 10 flies were added to each vial. The observation period spanned 3 days, monitoring for any signs of mortality. Based on the observed mortality, the LD50 (lethal dose for 50% of the population) was calculated. In a separate process, flies were subjected to rotenone induction by exposure to 0.197 μ g/ml of rotenone through the media for 7 days, aiming to induce PD[14, 15].

Grouping of Flies

After bottles with eggs was placed 23 °C to allow for developmental acclimation, the files was divided into five groups the control group consisted of 10 files receiving normal treatment. The disease group comprised 10 files treated with 0.197 μ g/ml of rotenone orally via culture media over a 7-day induction period. The standard group included 10 files treated with 0.5mg/ml of levodopa and 0.05mg/ml of carbidopa for 7 days, administered orally via culture media alongside a vehicle. Two additional groups, Dose 1 and Dose 2, each comprised 10 files treated with 400 μ g/ml and 160 μ g/ml of *cedrus deodara*, respectively, for 7 days via oral administration through culture media. Evaluation parameters included behavioural parameters such as climbing assay, T-maze test, and courtship assay was done.

Behavioural Studies

Climbing Assay

Following a seven-day induction period, the climbing index of all flies was assessed. Climbing chambers were fashioned by vertically taping two clear plastic vials together, with a designated height of 10 cm marked around the tube's circumference. The flies were introduced into their climbing chambers, allowing a minute for acclimation before the assay. To initiate the assay, the bottom of the tube was tapped to prompt climbing, and a timer was initiated. After 10 seconds, the flies that successfully completed the climb were tallied. All flies were simultaneously tested, commencing with the control group. Control and experimental groups underwent sequential testing to permit rest and recovery between the ten conducted trials per group. The count of successful flies per trial was documented as a percentage of the total flies within each treatment group.

T maze assay

The experimental assays utilized a glass T-maze shaped with dimensions of (14×10 cm, 08 mm, junctions 02 mm) connected to a starting chamber of a standard *Drosophila* vial, 9×2.5 cm and two odour chambers positioned on each side of the T-maze, all arranged horizontally (refer to Figure 2). The odour chambers the standard *Drosophila* vials, housed 20 μ l of the test compounds applied to filter paper sections(1×2cm). The test compound, derived from consecutive dilutions of the pure odourant in the distilled water, ensured a consistent dose presentation regardless of water solubility. To achieve this, each solution was vortexed before being pipetted onto the filter paper. Despite the absence of controlled airflow from outside, efficient diffusion of odourants into the central chamber was confirmed, as demonstrated in similar experiments investigating olfactory learning and preferences in fruit flies. This efficacy is further supported by dose-response curves, indicating the flies ability to detect changes in dosage. This setup proves particularly suitable for high-throughput tests. In the initial phase, the experiment a group of 100 flies is situated in the starting chamber of a T-maze apparatus, all chambers oriented horizontally. The flies have the liberty to explore the apparatus and access the lateral arms (odour chambers) of the T-maze, where odourants diffuse through. Following a 4-hour period of food deprivation in a standard *Drosophila* vial, the flies are released into the apparatus and given a 60-minute window for exploration before concluding the experiment. To prevent a second choice, the





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odour chambers are replaced with new vials containing the same odourant after half of the allocated time. Throughout the trial, each T-maze is enclosed within an isolated chamber (50×40×20cm) with symmetrical illumination. At the trial's conclusion, the count includes the number of flies entering each odour chamber in the first and second periods and the number of surviving flies that remain in the starting vial. With these data we calculated Olfactory preference is equal to the number of flies that chose odourant A divided by the number of flies that choose the odourant A added blank and the Choice ratio is equal to the number of flies that entered one of the odour chambers divided by the number of flies that entered one of the odour chambers added to the number of alive flies that did not enter any odour chamber. In Odour vs Blank experiment we tested the preference for an odourant vs. blank.

Courtship Assay

For courtship assay, flies utilized was housed in a small opaque container. Considering the diel periodicity of the *Drosophila* courtship behavior, assay took place between 9:00am and 15:00pm. A 6-day-old virgin male and virgin female were introduced into the cylindrical transparent chamber for a duration of 10 min or until the copulation ensued. A careful record of the flies interactions was recorded[16].

RESULTS AND DISCUSSION

Statistical Analysis

The statistical analysis of the data obtained from behavioural parameters following Rotenone infusion and drug treatment in *Drosophila* was performed using Graph pad prism software version 9.5.1. The data was represented as the mean ± SEM. The result was analyzed using one-way analysis of variance, ANOVA followed by Tukey's multiple comparison test. The value of $p < 0.05$ got was considered statistically significant.

Acute toxicity Study for Calculation of LD50 of *CedrusDeodoura* extract

Acute toxicity Study for Calculation of LD50 of *CedrusDeodoura* extract In 0.8mg of *Cedrus deodara* extract 50% flies were dead, hence based on mortality 0.8mg *Cedrus deodara* extract is considered as LD 50 value. Effect of *CedrusDeodoura* extract on locomotory through climbing assay. Treating with high dose of *Cedrus Deodara* extract(160µg/ml) has shown significant improvement in locomotor disabilities compared to diseased group.

All values was expressed in MEAN±SEM, n=10, statistical analysis was performed by employing one-way ANNOVA followed by Tukey's Multiple Comparison test. ****P value <0.05 when compared to the disease control and ****P value < 0.05 when compared to the treatment control.

Effect of *CedrusDeodoura* extract on chemoperception through T maze assay

Treating with high dose of *Cedrus Deodara* extract(160µg/ml) has shown significant improvement in olfactory function compared to diseased group. Statistical analysis was performed by employing one-way ANNOVA followed by Tukey's Multiple Comparison test, ****P value <0.05 when compared to disease control, ****P value < 0.05 when compared to treatment control.

Effect of *CedrusDeodoura* extract on sexual behaviour through courtship Assay

Treating with high dose of *Cedrus Deodara* extract(160µg/ml) has shown significant improvement in sexual behaviour compared to diseased group. Statistical analysis was performed by employing one-way ANNOVA followed by Tukey's Multiple Comparison test, ****P value <0.05 when compared to disease control, ****P value < 0.05 when compared to treatment control.





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CONCLUSION

The results shows that rotenone administration induces Parkinson's at a dose of 0.197µg/ml for a period of 7 days in *Drosophila melanogaster*. Treating with high dose of *Cedrus Deodara* extract helps in improving olfactory function, locomotor disabilities and sexual behaviour compared to diseased group. Hence the study shows that the administration of *Cedrus Deodara* extract produces anti-Parkinson's effect in Rotenone induced Parkinson's model based on the behavioural assessment.

ABBREVIATIONS

PD- Parkinsons Disease,
OS-Oxidative stress,
MAO- Monoamine oxidase,
COMT -Catechol O-methyl transferase,
MPTP- 1-methyl-4-phenyl1,2,3,6-tetrahydropyridine,
6-OHDA -6-hydroxydopamine,
NMDA- N-Methyl-D-aspartic acid,
ROS- Reactive oxygen species,
ND- Neurodegenerative disease,
αsyn -Alpha synuclein,
OK flies- Origano k flies,
ERK -Extra cellular signal-regulated kinase,
PKA-Protein kinase A,
GAD67- Glutamic acid Decarboxylase 67,
ATP -Adenosine triphosphate,
L-DOPA- L-3,
4-dihydroxyphenylalanine.

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Table 1 : Effect of *CedrusDeodoura* extract on locomotory through climbing assay

Groups	Trail 1	Trail 2	Trail 3	Mean±SED
Normal flies	9	9	8	8.666±0.577
Disease control	1	2	1	1.333±0.577
Standard	10	9	9	9.333±0.577
<i>cedrus deodara</i> Dose 1	9	10	9	9.333±0.577
<i>cedrus deodara</i> Dose 2	9	9	8	8.666±0.577

Table 2 : Effect of *CedrusDeodoura* extract on chemoperception through T maze assay

Groups	Trails									Olfactory preference	Choice ratio	Mean±SED
	1			2			3					
	O	B	T	O	B	T	O	B	T			
Normal flies	10	0	0	10	0	0	10	0	0	1	1	1±0
Disease control	1	0	9	2	0	8	1	0	9	1	0.1	0.166±0.0577
Standard	8	2	0	9	1	0	8	2	0	0.8	1	0.966±0.0577
<i>Cedrus deodara</i> Dose 1	9	1	0	8	2	0	9	1	0	0.9	1	0.966±0.0577
<i>Cedrus deodara</i> Dose 2	8	2	0	9	1	0	8	2	0	0.8	1	0.966±0.0577

Table 3: Effect of *CedrusDeodoura* extract on sexual behaviour through courtship Assay

Groups	trail 1	trail 2	trail 3	Mean±SED
Normal flies	9	9	8	8.666±0.577
Disease control	1	2	1	1.333±0.577
Standard	10	9	9	9.333±0.577
<i>cedrus deodara</i> Dose 1	9	10	9	9.333±0.577
<i>cedrus deodara</i> Dose 2	9	9	8	8.666±0.577





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<p>Figure 1 : Climbing Assay</p>	<p>Figure 2. T-maze used for behavioral assays</p>																								
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On Distance Pair Antimagic Labeling of Graphs

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ABSTRACT

A graph G is said to be distance antimagic if there is a bijection $f: V(G) \rightarrow \{1, 2, \dots, p\}$ such that for every pair of distinct vertices u and v applies $w(u) \neq w(v)$ where $w(v) = \sum_{u \in N(v)} f(u)$ and $N(v) = \{u \in V: uv \in E\}$ is the open neighborhood of v . A injective map $f: V(G) \rightarrow \{\pm 1, \pm 2, \dots, \pm p\}$ is said to be pair sum labeling if the induced edge function $f_e: E(G) \rightarrow \mathbb{Z} \setminus \{0\}$ defined by $f_e(uv) = f(u) + f(v)$ is one-one and $f_e(E(G))$ is either of the form $\{\pm k_1, \pm k_2, \pm k_3, \dots, \pm k_q\}$ or $\{\pm k_1, \pm k_2, \pm k_3, \dots, \pm k_{\frac{q-1}{2}}\} \cup \{\pm k_{\frac{q+1}{2}}\}$ according as q is even or odd. Based on idea of pair sum labeling, in this paper we introduced distance pair antimagic labeling by the extension of distance antimagic labeling and explores the results on such labeling. Further we investigated the relation between distance antimagicness and distance pair antimagicness of graphs.

Keywords: Graph labeling, distance magic, distance antimagic, pair sum labeling, distance pair antimagic labeling.

AMS Subject Classification(2010): 05C78

INTRODUCTION

All graphs consider here are finite, simple and undirected. The symbols $V(G)$ and $E(G)$ denote the vertex set and edge set of a graph G , terms and terminology are used sense of Harary [2]. The concept of *distance magic labeling* has been motivated by the construction of magic squares. A magic square of order n is an $n \times n$ array whose entries are an arrangement of the integers $1, 2, 3, \dots, n^2$ in which all elements in any row, any column, the main diagonal or the





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main back diagonal add to the same sum r . Now if we label the vertices of the complete n -partite graph with parts $|V_i| = n, 1 \leq i \leq n$, in such a way that the vertices of V_i are labeled with the integers in the i^{th} row of the magic square, then the sum of the labels of all the vertices in the open neighborhood of each vertex is the same and is equal to $r(n - 1)$. Motivated by this observation Vilfred [7] in his doctoral thesis introduced the concept of Σ -labeling. It is also called distance magic labeling [4]. In 2010, R. Ponraj[5] defined pair sum labeling of graphs and in 2013, Arumugam[3] introduced the concept of a distance antimagic labeling. Inspired the above works, we defined a distance antimagic labeling called distance pair antimagic labeling and discussed the following results.

MAIN RESULTS

Definition 2.1 Let G be a (p, q) graph. Let $f: V(G) \rightarrow P$ be a bijection where

$$P = \begin{cases} \pm 1, \pm 2, \dots, \pm \frac{p}{2}, & \text{if } p \text{ is even} \\ 0, \pm 1, \pm 2, \dots, \pm \frac{p-1}{2}, & \text{if } p \text{ is odd} \end{cases}$$

Then f is called a distance pair antimagic labeling if the induced weight function $w: V(G) \rightarrow W$ defined by $w(v) = \sum_{u \in N(v)} f(u) = k_i$ is one-one, where $N(v) = \{u \in V: uv \in E\}$ is the open neighborhood of v and the set of all weights W is either of the form $\{\pm k_1, \pm k_2, \pm k_3, \dots, \pm k_{\frac{p}{2}}\}$ or $\{0, \pm k_1, \pm k_2, \pm k_3, \dots, \pm k_{\frac{p-1}{2}}\}$ according as p is even or odd. A graph which admits distance pair antimagic labeling is called a distance pair antimagic graph.

Example 2.2.

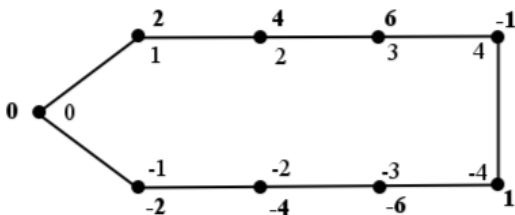


Figure 1: C_9 is a distance pair antimagic graph, here $W = \{0, \pm 1, \pm 2, \pm 4, \pm 6\}$.

Lemma 2.3 Let G be graph with two vertices u and v such that $N(u) = N(v)$, then G is not a distance pair antimagic graph.

Proof. Let $u, v \in V(G)$ and $N(u) = N(v)$. Then $w(u) = w(v)$ by definition.

Hence G is not a distance pair antimagic graph.

Example 2.4

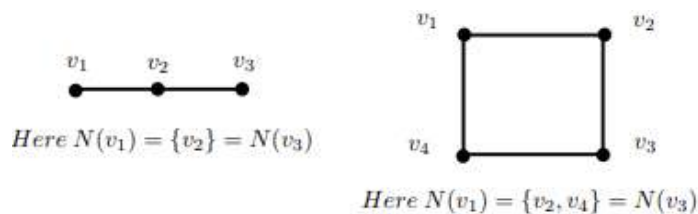


Figure:2 P_3 and C_4 are not distance pair antimagic graphs.

Theorem 2.5 The path P_n is a distance pair antimagic graph if $n \neq 3$.

Proof. We consider the following two cases:

Case (i): n is even and take $n = 2m$, where $m \geq 1$.





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Let $V = \{v_1, v_2, \dots, v_{2m}\}$ be the vertex set of P_{2m} .
 Define the labeling $f: V(P_n) \rightarrow \{\pm 1, \pm 2, \dots, \pm m\}$ by
 $f(v_i) = i, \text{ if } 1 \leq i \leq m$
 $f(v_{m+i}) = i - (m + 1), \text{ if } 1 \leq i \leq m$

The induced vertex weights labeling are

$$w(v_i) = \begin{cases} -1 & \text{if } i = m \\ 1, & \text{if } i = m + 1 \\ 2f(v_i), & \text{otherwise} \end{cases}$$

Clearly f is a distance pair antimagic labeling of P_n if n is even.

Case(ii): n is odd

for $n = 3, P_3$ is not a distance pair antimagic graph by Lemma 2.3.

Take $n = 2m + 1$, where $m = 2, 3, 4, 5, \dots$

Let the vertex set $V(P_n) = \{v_0, v_1, v_2, \dots, v_{2m}\}$ and a function $f: V(P_n) \rightarrow \{0, \pm 1, \pm 2, \dots, \pm m\}$.

Consider the following two subcases:

Subcase(a): $m = 2, 4, 6, \dots$

The labeling of vertices are as follows

$$f(v_i) = \begin{cases} 0, & \text{if } i = m \\ -(i + 1), & \text{if } 0 \leq i < m \\ n - i, & \text{if } i > m \end{cases}$$

Then the induced vertex weight labeling are as follows.

$$w(v_m) = 0;$$

$$w(v_{m-1}) = -(m - 1) = -w(v_{m+1});$$

$$w(v_i) = \begin{cases} -2(i + 1) & \text{if } 0 \leq i < m - 1 \\ 2(n - i) & \text{if } i > m + 1 \end{cases}$$

Subcase(b): $m = 3, 5, 7, \dots$

The labeling of vertices are as follows

$$f(v_0) = 1; f(v_1) = 0; f(v_{2m}) = -1$$

$$f(v_i) = \begin{cases} i, & \text{if } i < m + 1 \text{ and } i \text{ is even} \\ -(i - 1), & \text{if } i \leq m \text{ and } i \text{ is odd} \\ n - i, & \text{if } i \geq m + 1 \text{ and } i \text{ is even} \\ -(n + 1 - i), & \text{if } i > m \text{ and } i \text{ is odd} \end{cases}$$

Then the induced vertex weight labeling are as follows

$$w(v_0) = 0;$$

$$w(v_1) = 3 = -w(v_{2m});$$

$$w(v_2) = -2 = -w(v_{2m-1});$$

$$w(v_m) = n - 2 = -w(v_{m+1})$$

$$w(v_i) = \begin{cases} 2i, & \text{if } i < m - 1 \text{ and } i \text{ is odd} \\ -2(i - 1), & \text{if } i < m \text{ and } i \text{ is even} \\ 2(n - i), & \text{if } i > m \text{ and } i \text{ is odd} \\ -2(n + 1 - i), & \text{if } i > m + 1 \text{ and } i \text{ is even} \end{cases}$$

Clearly f is a distance pair antimagic labeling of P_n if n is odd and $n \neq 3$.

Hence P_n is a distance pair antimagic graph if $n \neq 3$.

Theorem 2.6 The cycle C_n is a distance pair antimagic graph if $n \neq 4$.

Proof. We consider the following two cases:

Case(i): n is even and take $n = 2m$, where $m \geq 3$.

Let $V = \{v_1, v_2, \dots, v_{2m}\}$ be the vertex set of C_n .

Define $f: V(C_n) \rightarrow \{\pm 1, \pm 2, \dots, \pm m\}$ by





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$$f(v_i) = \begin{cases} -i, & \text{if } i < m \\ m, & \text{if } i = m \\ -m, & \text{if } i = m + 1 \\ 2m + 1 - i, & \text{if } i > m + 1 \end{cases}$$

Then the induced vertex weight labeling are as follows.

$$\begin{aligned} w(v_1) &= -1 = -w(v_{2m}); \\ w(v_{m-1}) &= 2 = -w(v_{m+2}); \\ w(v_m) &= -(2m - 1) = -w(v_{m+1}); \\ w(v_{i+1}) &= -2(i + 1) = -w(v_{2m-i}) \text{ for } 1 \leq i \leq m - 3. \end{aligned}$$

Clearly f is a distance pair antimagic labeling of C_n , if n is even.

Case (ii) n is odd and take $n = 2m + 1$ where $m \geq 1$.

Let $V = \{v_0, v_1, v_2, \dots, v_{2m}\}$ be the vertex set of C_n .

Define $f: V(C_n) \rightarrow \{0, \pm 1, \pm 2, \dots, \pm m\}$ by

$$\begin{aligned} f(v_0) &= 0; \\ f(v_i) &= i, \text{ if } 1 \leq i \leq m; \\ f(v_i) &= i - n, \text{ if } m + 1 \leq i \leq 2m \end{aligned}$$

Then induced vertex weight labeling are

$$w(v_i) = \begin{cases} 0, & \text{if } i = 0 \\ -1, & \text{if } i = m \\ 1, & \text{if } i = m + 1 \\ 2f(v_i) & \text{otherwise} \end{cases}$$

Clearly f is a distance pair antimagic labeling of C_n , for odd n and hence C_n is a distance pair antimagic graph if $n \neq 4$.

Theorem 2.7 The complete graph K_n is distance pair antimagic for $n > 1$.

Proof. We consider the following two cases:

Case(i): n is even and take $n = 2m$. Let $V = \{v_1, v_2, \dots, v_{2m}\}$ be the vertex set of K_n .

Define $f: V(K_n) \rightarrow \{\pm 1, \pm 2, \dots, \pm m\}$ by

$$f(v_i) = \begin{cases} -\lfloor \frac{i}{2} \rfloor, & \text{if } i = 1, 3, 5, \dots, 2m - 1 \\ \frac{i}{2}, & \text{if } i = 2, 4, 6, \dots, 2m \end{cases}$$

Then vertex weights are

$$w(v_i) = \begin{cases} \lfloor \frac{i}{2} \rfloor, & \text{if } i = 1, 3, 5, \dots, 2m - 1 \\ -\frac{i}{2}, & \text{if } i = 2, 4, 6, \dots, 2m \end{cases}$$

Case(ii): n is odd and take $n = 2m + 1$.

Let $V = \{v_0, v_1, v_2, \dots, v_{2m}\}$ be the vertex set of K_n .

Define $f: V(K_{2m+1}) \rightarrow \{0, \pm 1, \pm 2, \dots, \pm m\}$ by

$$f(v_i) = \begin{cases} 0, & \text{if } i = 0 \\ -\lfloor \frac{i}{2} \rfloor, & \text{if } i = 1, 3, 5, \dots, 2m - 1 \\ \frac{i}{2}, & \text{if } i = 2, 4, 6, \dots, 2m \end{cases}$$

Then vertex weight are $w(v_i) = -f(v_i)$. Clearly f is a distance pair antimagic labeling of K_n and hence K_n is distance pair antimagic.

Theorem 2.8 The complete bipartite graph $K_{n,m}$ is distance pair antimagic graph if and only if $n = m = 1$.





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Proof.Case(i): $n = m = 1$

By theorem 2.5, the complete bipartite graph $K_{1,1}$, is nothing but the path P_2 is a distance pair antimagic graph.

Case(ii): $n \geq 1$ and $m > 1$

Let V_1 and V_2 be bipartition of $V(K_{n,m})$. For any two vertices $u, v \in V_1$ then $N(u) = N(v) = V_2$. By lemma 2.3, $K_{n,m}$ is not a distance pair antimagic graph.

Theorem 2.9 The ladder graph $L_n = P_n \times P_2$ is distance pair antimagic for $n \geq 3$.

Proof.

Let $V(L_n) = \{u_i, v_i: 1 \leq i \leq n\}$ and $E(L_n) = \{u_i u_{i+1}, v_i v_{i+1}: 1 \leq i \leq n-1\} \cup \{u_i, v_i: 1 \leq i \leq n\}$ be the vertex set and edge set of L_n .

Define $f: V(L_n) \rightarrow \{\pm 1, \pm 2, \dots, \pm n\}$ by

$$f(u_i) = \begin{cases} i, & \text{if } 1 \leq i \leq n-1 \\ -n & \text{if } i = n \end{cases}$$

$$f(v_i) = \begin{cases} -i, & \text{if } 1 \leq i \leq n-1 \\ n & \text{if } i = n \end{cases}$$

Then the induced vertex weight labeling are as follows.

$$w(u_i) = i = -w(v_i), \text{ if } 1 \leq i \leq n-2;$$

$$w(u_{n-1}) = -(n+1) = -w(v_{n-1});$$

$$w(u_n) = 2n-1 = -w(v_n).$$

Clearly f is a distance pair antimagic labeling of $P_n \times P_2$ and hence L_n is a distance pair antimagic graph.

Theorem 2.10 If G is a distance pair antimagic graph with even number of vertices, then the join graph $G + K_1$ is a distance pair antimagic graph.

Proof. Let G be a distance pair antimagic graph and $|V(G)| = 2m$ where $m = 1, 2, 3, \dots$

Then there exist a distance pair antimagic labeling $f: V(G) \rightarrow \{\pm 1, \pm 2, \dots, \pm m\}$.

Take $V(K_1) = u$ and $V(G) = \{v_1, v_2, \dots, v_{2m}\}$, then $V(G + K_1) = \{u, v_1, v_2, \dots, v_{2m}\}$.

Now define $f^*: V(G + K_1) \rightarrow \{0, \pm 1, \pm 2, \dots, \pm m\}$ by

$$f^*(u) = 0;$$

$$f^*(v_i) = f(v_i) \text{ for } i = 1, 2, 3, \dots, 2m$$

Then the induced vertex weight labeling are as follows.

$$w^*(u) = 0;$$

$$w^*(v_i) = w(v_i) \text{ for } i = 1, 2, 3, \dots, 2m$$

Hence f^* is a distance pair antimagic labeling of $G + K_1$.

Theorem 2.11 If G is a distance pair antimagic graph, then tG is also a distance pair antimagic graph, where tG is t copies of G .

Proof. Let f be a distance pair antimagic labeling of G and $G_1, G_2, G_3, \dots, G_t$ be t copies of G .

Let the vertex set of i^{th} copy of G be $v_1^i, v_2^i, \dots, v_n^i$.

We consider the following two cases:

Case(i): Suppose t is even and n is either odd or even.

The total number of vertices in $tG = nt$, which is even.

Define $f: V(tG) \rightarrow \{\pm 1, \pm 2, \dots, \pm \frac{nt}{2}\}$ by

$$f(v_j^i) = j + \frac{nt}{2} \left(\frac{i-1}{2} \right), i = 1, 3, 5, \dots, t-1 \text{ and } j = 1, 2, 3, \dots, n$$

$$f(v_j^i) = - \left[j + \frac{nt}{2} \left(\frac{i-1}{2} \right) \right], i = 2, 4, 6, \dots, t \text{ and } j = 1, 2, 3, \dots, n$$

Case(ii): t is odd and take n is either odd or even.





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Let f_1 be a distance pair antimagic labeling of G .
 Assign the labels $\{0, \pm 1, \pm 2, \dots, \pm \frac{n}{2}\}$ or $\{\pm 1, \pm 2, \dots, \pm \frac{n}{2}\}$ into the vertices of t^{th} copy of G accordingly n is odd or n is even by f_1 .

Assign following labeling f_2 for first $t - 1$ copies of G ,

$$f_2: V((t - 1)G) \rightarrow \left\{ \pm \left(\frac{n}{2} + 1 \right), \pm \left(\frac{n}{2} + 2 \right), \dots, \pm \frac{n(t-1)}{2} \right\} \text{ by}$$

$$f_2(v_j^i) = j + \frac{n}{2} \left(\frac{i+1}{2} \right), i = 1, 3, 5, \dots, t - 2 \text{ and } j = 1, 2, 3, \dots, n$$

$$f_2(v_j^i) = - \left[j + \frac{n}{2} \left(\frac{i}{2} \right) \right], i = 2, 4, \dots, t - 1 \text{ and } j = 1, 2, 3, \dots, n$$

Clearly f_1 and f_2 are distance pair antimagic labeling of tG . Hence tG is distance pair antimagic graph.

Corollary 2.12 *If a graph G is distance pair antimagic with even number of vertices, then $tG + K_1$ is also distance pair antimagic.*

Proof. By theorem 2.11, tG is distance pair antimagic graph. By the definition of joining of two graphs, join each vertex of tG to a single vertex u and labeled as zero. Then $tG + K_1$ is distance pair antimagic graph.

Relation between distance antimagic and distance pair antimagic labeling

Arumugam and Kamatchi [3] has been proposed the following conjecture.

Conjecture

A graph G is distance antimagic if and only if $N(u) \neq N(v)$ for any two distinct vertices u and v in G .

This conjecture not exist for distance pair antimagic labeling by the following theorem.

Theorem 3.1 *The wheel graph $W_n = C_{n-1} + K_1$ is distance pair antimagic iff $n = 7, 9, 11, \dots$ or $n = 4$.*

Proof. Let W_n be a wheel graph, where $n = 4, 5, 6, 7, \dots$

Suppose $n = 7, 9, 11, \dots$ or $n = 4$, by using theorems 2.4 and 2.8, the Wheel graph W_n is distance pair antimagic, because $W_n = C_{n-1} + K_1$.

Hence W_n is a distance pair antimagic graph, if $n = 7, 9, 11, \dots$ or $n = 4$.

Conversely, if W_n is a distance pair antimagic graph, then we prove $n = 7, 9, 11, \dots$ or $n = 4$.

It is enough to prove that if W_n is a not distance pair antimagic graph, if $n = 2m$ where $m \geq 3$ and W_5 .

By lemma, W_5 is not a distance pair antimagic graph.

Assume that W_{2m} is a distance pair antimagic graph if $m \geq 3$.

Then there exist a distance pair antimagic labeling $f: V(W_{2m}) \rightarrow \{\pm 1, \pm 2, \pm 3, \dots, \pm m\}$.

Let $\{v_0, v_1, v_2, \dots, v_{2m-1}\}$ be the vertices of W_{2m} and v_0 be the apex vertex and remaining vertices $\{v_1, v_2, v_3, \dots, v_{2m-1}\}$ be rim vertices of W_{2m} .

Consider following two cases.

Case(i): Assign $f(v_0) = l$, where $l \in \{1, 2, 3, \dots, m\}$. Then $w(v_0) = -l$

We know that any distance pair antimagic graph has exactly two vertices receives, maximum weight and minimum weight, so that we can choose two rim vertices u and v such that

$$w(u) = \max \{w(v_0), w(v_1), \dots, w(v_{2m-1})\} \text{ and}$$

$$w(v) = \min \{w(v_0), w(v_1), \dots, w(v_{2m-1})\} \text{ with } w(u) + w(v) = 0 \rightarrow (1)$$

Since u and v are rim vertices, which receives labels l_1, l_2, l and l_3, l_4, l respectively in its weight where $l_1, l_2 \in \{1, 2, 3, \dots, m\} - \{l\}$ and $l_3, l_4 \in \{-1, -2, -3, \dots, -m\}$ with

$$l_1 + l_2 + l_3 + l_4 = 0, \text{ then the equation (1) } \Rightarrow w(u) + w(v) = 0$$

$$\Rightarrow (l_1 + l_2 + l) + (l_3 + l_4 + l) = 0 \Rightarrow 2l = 0 \Rightarrow l = 0, \text{ which is a contradiction to our assumption that } l \text{ is a positive integer and hence } W_n \text{ is not a distance pair antimagic graph for } n = 2m \text{ and } m \geq 3$$

Case(ii): Assign $f(v_0) = l$, where $l \in \{-1, -2, -3, \dots, -n\}$.

As in case(i), we can prove case (ii). Hence the wheel graph W_n is a distance pair antimagic iff $n = 7, 9, 11, \dots$ or $n = 4$.





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Theorem 3.2 If G is any distance antimagic graph, then the disjoint union $G \cup G$ is a distance pair antimagic graph.

Proof. Let G be any distance antimagic graph with n vertices. Then there exist a bijection $f: V(G) \rightarrow \{1, 2, \dots, n\}$, such that $w(v_i) \neq w(v_j)$ for $i \neq j$.

Take another copy of G and define $f^*: V(G) \rightarrow \{-1, -2, \dots, -n\}$ by

$$f^*(v_i) = -f(v_i) \text{ for all } i.$$

Then induced vertex weight labeling are $w^*(v_i) = -w(v_i)$ for all i .

Hence $G \cup G$ is a distance pair antimagic graph.

CONCLUSION AND SCOPE

In this paper we have introduced and investigated the existence of distance pair antimagic labeling on standard family of graphs. Further we proved the disjoint union of G , $tG + K_1$ and complement of $G \cong C_n$ a distance pair antimagic graph if G is a distance pair antimagic graph. By the observation of Conjecture 3.2 in [3], we have the following the conjecture:

Conjecture

A tree T is distance pair antimagic iff every support vertex v has exactly one leaf adjacent to v . By corollary 2.11, by replacing G by P_n , we obtained the graph $S_k(K_{\{1,n\}})$ (as defined in [3]) and this serves as one of the particular case of the above conjecture. Further we a scope for characterisation of distance pair antimagicness of trees.

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Experimental Investigation of Mechanical Properties of Geopolymer Concrete using Hybrid Fibers

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ABSTRACT

Conventional Concrete, commonly manufactured using Portland cement, is a staple in construction, with its demand steadily rising. Concrete production was projected to increase from 1.5 to 2.2 billion tons between 1995 and 2015. However, the industry's significant contribution to CO₂ emissions, about 6%, exacerbates climate change, with CO₂ responsible for 65% of global warming. Efforts to mitigate these emissions include exploring alternative materials like fly ash, silica fume, and geopolymer technology. Geopolymer, proposed by Davidovits, shows promise, potentially reducing CO₂ emissions by 80%. This research work aims to investigate fiber-based geopolymer concrete properties incorporating glass and crimped steel fibers. Utilizing low-calcium fly ash (ASTM Class F), GGBS, and alkaline solution, the study examines compressive, flexural, and split tensile strength, and was analyzed on various compositions of fibers. Objectives include identifying parameters affecting properties and developing a mix proportioning process.

Keywords: Crimped Steel Fiber, Glass Fiber Ground granulated blast furnace slag, Fly-Ash, Geopolymer Concrete

INTRODUCTION

The first geopolymer cement was developed in the 1980s was of the type (K,Na,Ca)-poly(sialate) (or slag-based geopolymer cement) and resulted from the research developments carried out by Joseph Davidovits and J.L. Sawyer

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at Lone Star Industries, USA and yielded the invention of Pyrament cement. Geopolymers have been known to be useful binders in concrete for over decades, but have recently developed rapidly in Australia due to the fact they have a CO₂ footprint which is approximately 80% lower than OPC cement. Water, expelled from the geopolymer matrix during the curing and further drying periods, leaves behind nano-pores in the matrix, which provide benefits to the performance of the geopolymer. The water in a low-calcium fly ash-based geopolymer mixture, therefore, plays no direct role in the chemical reaction; it merely provides the workability to the mixture during handling. This is in contrast to the chemical reaction of water in a Portland cement concrete mixture during the hydration process. However, a small proportion of calcium-rich source materials such as slag may be included in the source material to accelerate the setting time and to alter the curing regime adopted for the geopolymer mixture. In that situation, the water released during the geopolymerisation reacts with the calcium present to produce hydration products.

Slag Based Geopolymer

The first geopolymer developed was slag-based in the 1980s. The reason for using this type of cement is due to its rapid strength gain as it can reach strengths of up to 20 MPa after just 4 hours. Slag is a partially transparent material and a by-product of melting iron ore. It usually consists of a mixture of metal oxides and silicon dioxide. It is also used in the cement and concrete industry. The substitution of OPC with slag is one of the many benefits that it provides to OPC concrete, reducing life cycle costs and improving the workability of the fresh concrete, Easier finish ability, higher compressive and flexural strength, and also improved resistance to acid materials. The reactions of slag in alkali activating systems and cement blends are dominated by the small particles. The particles above 20 µm usually react slowly, while particles under 2 µm react completely within 24 hours. Thus, when slag is used in polymerization, careful control of the particle size distribution must be ensured to control the strength of the binder.

Rock-Based Geopolymer

To compose this type of geopolymer, a fraction of the MK-750 (“MK” is an abbreviation for Metakaolin, and the “750” represents the temperature at which it was produced) in the slag-based geopolymer is replaced by natural rock-forming materials such as feldspar and quartz. This mixture yields a geopolymer with better properties and less CO₂ emissions than that of the ordinary slag-based geopolymer. The components of rock-based geopolymer cement are Metakaoline MK-750, blast-furnace slag, natural rock-forming materials (calcined or non-calcined), and a user-friendly alkali silicate.

Fly Ash Based Geopolymer

Fly ash is the waste material produced in the blast furnace. Components of fly ash are amorphous composition (60%), quartz (20%), mullite (17%), magnetite (1.7%), and hematite (.9%). Fly ash is commonly used as a substitute for OPC in concrete and the addition of it provides that fly ash consists of spherical particles as shown in Fig:2 which improves the workability of the fresh OPC concrete. This enables one to reduce the amount of water in the mix which reduces the amount of bleeding of OPC concrete. It improves mechanical properties such as compressive strength, due to water reduction and ensures a higher reactivity and better “packing” of particles. Reduce the cost of the OPC concrete.

LITERATURE REVIEW

Patankar S. et al., (2018) studied the effect of duration and temperature curing on the compressive strength of fly-based Geopolymer Concrete (GPC) and observed while finding the effect of concentration of sodium hydroxide on fly ash-based geopolymer concrete that the compressive strength of geopolymer concrete increases with increase in the concentration of sodium hydroxide solution for all temperatures but the rate of gain of strength at and above 60°C is not very significant. **Zhang H.Y. et al., (2018)** based on their experimental results on the bond behavior between geopolymer concrete and rebar reported that Geopolymer concrete exhibits significant temperature-





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induced degradation in bond strength when exposed to temperatures above 300°C. Also, the Bond strength of geopolymer concrete was found to decrease at the same rate as that of splitting tensile strength with temperature, but this degradation is at a higher pace than that of the compressive strength. **Manimaran, E and Mohankumar, G. (2017)** investigated the influence of sodium hydroxide concentration on the strength of fly ash-based geopolymer concrete and reported that the strength of ambient cured specimens is always less and about 95% to 97% of the hot cured concrete irrespective of the molarity of NaOH solution. Under specified concentrations of NaOH, the required strength of Geopolymer concrete can be achieved by ambient curing itself and hot curing is not at all required under laboratory conditions. Hot curing may be employed in the case of fabrication of precast units. **Ukesh Praveen P and Srinivasan K (2017)** conducted a review of the literature about the self-compacting of geopolymer concrete and reported that the contribution of GGBS helps the self-compacting geopolymer concrete attain high compressive strength at ambient room temperature. GGBS at ambient curing conditions had more compressive strength rather than Fly ash-based self-compacting geopolymer concrete. It is recommended that sodium hydroxide and sodium silicate solutions should be prepared at least 24 hours before use.

Adam A. A. et al., (2016) investigated the effect of lime addition on the setting time strength of ambient cured fly ash-based geopolymer concrete and reported that the setting time of the class F fly ash-based geopolymer paste can be controlled by adding a small proportion of slaked lime. The addition of lime increases the strength and decreases the setting time. **Sandeep L. Hake et al., (2015)** investigated the method of curing and found that most researchers used only oven heat curing for geopolymer concrete. They reported that many studied only different curing temperatures in oven curing, but only a few researchers experimented with steam, and membrane curing, and no work was reported on accelerated curing, as well as comparison on steam, accelerated, membrane, natural, and oven curing. So there is scope for research on the method of curing of geopolymer concrete. **Ganesan N, Ruby Abraham, and S. Deepa Raj (2015)** studied the effect of fibers on the durability characteristics of geo-polymer concrete and compared it with conventional concrete of the same grade. The durability parameters considered in this study include water absorption, abrasion resistance, resistance to chemical attack, effect of alternate wetting and drying, and resistance against chloride ions. They concluded that geo polymer concrete possesses better durability characteristics than conventional concrete of the same grade and the addition of fibers further improved the durability characteristics of GPC. **Parda et al., (2014)**. The combination of Ground granulated blast-furnace slag (GGBS) with class F fly ash can have a significant effect on the setting and compressive strength development of geopolymer concrete.

The effect of different proportions of GGBS and activator content on the workability and strength properties of fly ash-based geopolymer concrete. The test result showed that 28-day compressive strength reached up to 51 MPa in geopolymer concrete containing 20% slag and 80% fly ash in the binder and 40% activator liquid with an SS/SH ratio of 1.5 when cured at 20 C. **Ganesan et al., (2014)** the effect of hybrid fibers on the strength and behavior of High performance concrete beam-column joints subjected to reverse cyclic loads was studied. The addition of fibers in hybrid form improved many of the engineering properties such as the first crack load, ultimate load, and ductility factor of the composite. The combination of a 1% volume fraction of steel fibers and a 0.15% volume fraction of polypropylene fibers gave a better performance concerning energy dissipation capacity and stiffness degradation than the other combinations. **Pradip et al., (2014)** Study was conducted on the geopolymer concrete cured under ambient conditions. Fly ash and GGBS-based geopolymer concrete for curing by ambient conditions can be proportioned for desirable workability, setting time, and compressive strength using ground granulated blast-furnace slag (GGBS) as a small part of the binder. The inclusion of GGBS with Class F fly ash helped achieve setting time and compressive strength comparable to those of ordinary Portland cement (OPC). **K. Parthiban et al., (2013)**, studied the influence of the various proportions of GGBS (0 to 100%) and the effect of the amount of Alkaline Activated Solution (AAS) on the compressive strength of geopolymer concrete which is cured under ambient temperature conditions. The molarity of the sodium hydroxide solution was maintained constant. They observed that the compressive strength of the GPC increased with the increase in the percentage of GGBS and also with the increase in the amount of the sodium silicate solution. **Deepa Balakrishnan S et al., (2013)** reported that the fly ash content is much more significant when the geo-polymer concrete is cured at ambient temperature. However, the



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change in strength of heat cured specimen is nominal with the variation of fly ash content varied from 395 to 425 kg per cubic meter of concrete. They reported that the fly ash geo-polymer concrete is a sustainable material for future construction works. However, design methodologies are to be developed for geo-polymer concrete before actual use in worksite. **Swanepoel, J.C and Strydom, C.A (2013)** prepared the GPC by mixing fly ash, kaolinite, Na_2SiO_3 , NaOH, and water. The samples were cured at 40, 50, 60, & 70°C for different time intervals (6, 24, 48, and 72 hours) the compressive strength testing was performed at the age of 7 & 28 days using 3 members 50mm cubic samples. The authors reported that the optimum curing condition for polymerization was 60°C for 48 hours. Compressive strength measurements show a maximum strength of almost 80 MPa after 28 days. **Deepa Balakrishnan S. et al., (2013)** examined the properties of fly ash-based geopolymer concrete and stated that the strength gain in geopolymer concrete is significant when heat cured for 72 hours also the strength of heat-cured specimen is found to be almost equal to the corresponding strength of 90 day ambient cured specimens or almost two times as that of the 28-day strength. **Satpute Manesh B. et al., (2012)** studied the effect of duration and temperature curing on the compressive strength of fly ash based on geopolymer concrete and reported that curing temperature and duration are important in the activation of geopolymer concrete. Curing time, in the range of 6 to 24 hours, produces higher compressive strength. However, the increase in strength beyond 20 hours is not significant. **Gokulram H. et al., (2012)**, conducted an experimental investigation on the mechanical properties of different binder compositions of Geopolymer Concrete Composites (GPCC). The study analyses the effect of polypropylene fiber on mechanical properties such as compressive strength, split tensile strength, and flexural strength of hardened GPCC. Polypropylene fibers were added to the mix in the volume fraction of 0.25% volume of concrete. Two kinds of systems were considered in this study using 100% replacement of cement by ASTM class F Fly ash and ground granulated blast furnace slag and 100% replacement of natural sand by Manufactured sand. The mix with 100% GGBS and 0% FA has given the highest mechanical properties i.e. compressive strength of 34 N/mm², split tensile strength of 4.74 N/mm², and flexural strength of 5.1 N/mm². **Ganapati Naidu P et al., (2012)**, evaluated the different strength properties of GPC by replacing fly ash with GGBS and making workable, high-strength, and durable concrete without the usage of OPC. Fly ash was collected from the National Thermal Power Corporation (NTPC), Visakhapatnam. The sodium hydroxide solution is mixed with sodium silicate solution to get the desired alkaline solution one day before casting. Ambient curing has been adopted for the specimens.

From the tests, it was concluded that higher concentrations of GGBS result in higher compressive strength. Beyond 30% replacement of GGBS, immediate setting was observed. To attain maximum strength 9% of fly ash is replaced by GGBS in the aspect of ambient and combusted curing. Compressive strength increases with an increase in GGBS. A maximum of 25% loss in compressive strength was observed when the specimen was exposed to a temperature of 500°C for two hours. 90% of compressive strength was achieved in 14 days. The average density of geopolymer concrete was equal to that of OPC. **Shakor & Pimplikar et al., (2011)** Concluded that 7 days average compressive strength of concrete is maximum when 1.5 % of glass fibers by weight of cementitious material are used. At lower 0.11% of glass fibers or higher 2 % of glass fibers, about 15% to 20% reduction in strength was observed nevertheless at 28 days, the reduction in strength approaches to 5% to 10%. The percentage of glass fiber of 2% gave a flexural strength of 6.15 MPa, which is 10% more than that obtained at 1.5%. **P. Sangeetha et al., (2011)** reported that an increase in the percentage of glass fiber by weight of concrete (0.1%, 0.2% & 0.3%) increases the compressive and impact strength. The percentage increase in compressive strength was reported to be up to 23%. **Jalal Rouhiet al., (2011)**, studied the effect of polypropylene fibers on the compressive strength, permeability, and electric resistivity of concrete samples. The concrete samples were made with fibers ranging from 0 to 2 kg/ m³. Electrical resistivity and compressive strength of concrete samples with fiber ratios of 1.5 kg/ m³ had higher values and the permeability of the concrete specimens reduced as the fiber content increased. Samples with a fiber content of 1.5 kg/ m³ showed optimum results in comparison with other samples. **H. Sudarsana Rao, M. Safari Tabalvandani, Krishan Rao MV et al., (2011)** Stated that the workability of glass fiber-reinforced high-performance concrete mixes decreases with an increase in the percentage of glass fibers. The work of different researchers on GFRC has been found on concretes cast by using foreign ingredients only. The trend of locally branded concretes manufactured by using indigenous materials found in Pakistan was still demanding a lot of research work. The current investigation was planned to explore the effects of using different percentages of glass fibers on properties of fresh and hardened concrete like



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workability, compressive strength, tensile strength, flexural strength, and ultrasonic pulse velocity. **Hardijto, D.Wallah S.E., Sumajouw D.M.J., and Rangan, B.V(2009)** investigated the effect of various synthesizing parameters on fly ash-based geopolymer concrete. Numerous bathes of geopolymer concrete were prepared by activated class-F fly ash with sodium silicate and sodium hydroxide solutions.

Objective of Current Study

The main objective of this research work is

- To develop a mixture proportioning process to manufacture fiber-based geopolymer concrete.
- To identify and study the effect of salient parameters that affect the properties of fiber-based geopolymer concrete.

Materials Used

Fly-Ash

Defined as 'the finely divided residue that results from the combustion of ground or powdered coal and that is transported by flue gasses from the combustion zone to the particle removal system' (ACI Committee 232 2004), Fly-Ash could be considered as an Environmental Waste material, is commonly used as substitutive Cementitious Materials in the modern concrete practice. The fly ash used for this project is collected and transported from NTPC Ramagundam, possessing the Chemical Composition as stated in Table: 1 below

Ground Granulated Blast Furnace Slag(GGBS)

Obtained by quenching molten iron slag from a blast furnace in water or steam, dried and ground into a fine powder. Its use results in lower heat of hydration and lower temperature rises, further it reduces the risk of damages caused by alkali-silicereactions. Provides higher resistance to chloride ingress reducing the risk of reinforcement corrosion and provides higher resistance to attacks by Portland cement sulphate and other chemicals. This study has used the GGBS from a Local RMC Plant possessing the Chemical Composition as stated in Table: 2.

Alkaline Activators

A combination of sodium silicate solution and sodium hydroxide solution was chosen as the alkaline activators. The sodium hydroxide solids were in pellet form (3 mm), with a specific gravity of 1.51 and 98% purity, and were used to achieve 8M Sodium Hydroxide Solution (NaOH) (320 grams/liter). Sodium Silicate Solution (Na_2SiO_3) with 50.32% Solid Content was also, where NaOH to Na_2SiO_3 ratio was maintained as 2.5.

Glass Fiber

Glass Fiber is a material consisting of numerous extremely fine Fibers of glass. It is used as a thermal insulating material and is specially manufactured with a bonding agent to trap many small air cells, resulting in the characteristically air-filled low-density "glass wool" family of products. The Mechanical Properties of the Glass Fibers used for this study are stated in Table: 4 below. Glass Fiber has roughly comparable mechanical properties to other Fibers such as polymers and carbon Fiber. Although not as strong or as rigid as carbon Fiber, it is much cheaper and significantly less brittle when used in composites. Glass Fibers are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight Fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), also popularly known as "Fiberglass". This material contains little or no air or gas, is denser, and is a much poorer thermal insulator than glass wool.

Crimped Steel Fiber

This study has used crimped stainless steel Fibers. The use of Fibers in concrete has the property of resistance against cracking and crack propagation. The Fiber composite pronounced post cracking ductility which is unheard of in ordinary concrete. The transformation from a brittle to a ductile type of material would increase substantially the energy absorption characteristics of the Fiber composite and its ability to withstand repeatedly applied shock or





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impact loading. These Fibers are short, discrete lengths having an aspect ratio in the range of 20-100, with any cross-section that is sufficiently small to be randomly dispersed in an unhardened concrete. Further, they are low-carbon, cold-drawn steel wire Fibers designed to provide concrete with temperature and shrinkage crack control, enhanced flexural reinforcement, improved shear strength, and increased crack resistance of concrete. These steel macro-fibers will also improve impact, shatter, fatigue, and abrasion resistance while increasing the toughness of concrete. Dosage rates will vary depending upon the reinforcing requirements and can range from 15 to 60 kg/m³.

METHODOLOGY

- Under various trials and errors, GPC of grade 50 MPa was prepared and achieved, with a Fly-Ash: GGBS ratio of aof0.5 and NaOH to Na₂SiO₃ ratio of2.5., the GPC Specimens were subjected to Ambient Curing.
- Additives such as binders, super plasticizers, and fibers were once as soon as quickly blended used in different proportions i.e 0.1% to 0.6%, and super plasticizer SP430 delivered in the concrete due to the reality of hindering the water content material cloth will make bigger strength. The strength of the cubes is tested for 3 days, 7 days, and 28 days using crimped steel fiber and glass fiber is graphically illustrated using the proportions in percentages from 0.1% to 0.6%.The maximum strength achieved for different proportions is graphically represented.
- The test consequences of compressive strength, flexural strength, and split tensile strength for cubes, beams, and cylinders uncovered to 0.1% to 0.6% of fibers with the aid of super plasticizers, GGBS, and alkaline solution and cured for 3 days, 7 days and 28 days by ambient curing produce the required strength.

RESULTS AND DISCUSSIONS

Compressive Strength Test results on G50 cubes using steel fibers

The Compressive Strength results of Plain G30 Cubes(150*150*150 mm) and using Steel Fibersare presented graphically in Fig: 1 and 2 below, and the inferences are as follows:

- From Fig:1, it is evident that the compressive strength of the concrete cubes is 23.4 N/mm² after 3 days, 46.8 N/mm² after 7 days, and 58.5 N/mm² after 28 days.
- The concrete cubes gained more strength between 3 and 7 days than they did between 7 and 28 days. This is because the rate of strength gain slows down as the concrete cures.
- The compressive strength of the concrete cubes after 28 days is 58.5 N/mm². This is a common target strength for concrete used in construction.
- From Fig:2, it could observed that the Steel fibers increase the compressive strength of M50 concrete cubes. This is evident from the fact that all the curves for the concrete mixes with steel fibers (0.10%, 0.20%, 0.30%, 0.40%, 0.50%, and 0.60%) are above the curve for the standard mix (0% fibers).
- The optimal percentage of steel fibers is 0.40%. The concrete mix with 0.40% steel fibers has the highest compressive strength at all curing times (3 days, 7 days, and 28 days). After 28 days, the compressive strength of the 0.40% mix is 62.3 N/mm², which is about 2% higher than the strength of the standard mix (60.2 N/mm²).
- Adding too many steel fibers can decrease the compressive strength. The compressive strength of the concrete mix with 0.60% steel fibers is lower than the compressive strength of the mix with 0.50% steel fibers at all curing times. This is because adding too many fibers can make the concrete mix difficult to work with and can lead to voids in the concrete.

Split tensile strength Test results on G50 Cylinders using steel fibers:

The Split Tensile Strength results of Plain G30 Cylinders (150mm dia and 300mm height) and using Steel Fibersare presented graphically in Fig: 3 and 4 below, and the inferences are as follows:

- From Fig: 3, it can be noticed that the Split Tensile Strength values have ranged from around 3.82 N/mm² to 4.82 N/mm².





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- And all the results were satisfactory since every result has fallen within the range of 8-15 % of Compressive Strength of Concrete.
- From Fig: 4, it can be seen that Steel fibers can increase the split tensile strength of M50 concrete cylinders. This is evident from the fact that all the curves for the concrete mixes with steel fibers (0.10%, 0.20%, 0.30%, 0.40%, 0.50%, and 0.60%) are above the curve for the standard mix (0% fibers).
- The optimal percentage of steel fibers is 0.40%. The concrete mix with 0.40% steel fibers has the highest split tensile strength at all ages (3 days, 7 days, and 28 days). After 28 days, the split tensile strength of the 0.40% mix is 5.48 N/mm², which is about 5.2% higher than the strength of the standard mix (5.2 N/mm²).
- Adding too many steel fibers can decrease the split tensile strength. The split tensile strength of the concrete mix with 0.60% steel fibers is lower than the split tensile strength of the mix with 0.50% steel fibers at all ages. This is because adding too many fibers can make the concrete mix difficult to work with and can lead to voids in the concrete.

Flexural strength Tests on G50 prisms using steel fibers:

The Flexural Strength results of Plain G30 Prisms (750*150*150 mm) and using Steel Fibers are presented graphically in Fig: 5 and 6 below, and the inferences are as follows:

- From Fig: 5, it can be noticed that the Flexural Strength values have ranged from around 1.81 N/mm² to 4.53 N/mm².
- And all the results were satisfactory since every result has fallen close to $(0.7 \cdot f_{ck}^{0.5})$ [f_{ck} : Compressive Strength of Concrete]
- From Fig:6, the Flexural strength of the M50 Prism increases with the addition of steel fibers. This is evident from the fact that all the curves for the concrete mixes with steel fibers (0.10%, 0.20%, 0.30%, 0.40%, 0.50%, and 0.60%) are above the curve for the standard mix (0% fibers).
- The optimal percentage of steel fibers for split tensile strength is 0.40%. The concrete mix with 0.40% steel fibers has the highest split tensile strength at all curing times (3 days, 7 days, and 28 days). After 28 days, the split tensile strength of the 0.40% mix is 4.9 N/mm², which is about 13.5% higher than the strength of the standard mix (4.3 N/mm²).
- Adding too many steel fibers can decrease the split tensile strength. The split tensile strength of the concrete mix with 0.60% steel fibers is lower than the split tensile strength of the mix with 0.50% steel fibers at all curing times. This could be due to several factors, such as fiber clumping or difficulty in achieving proper fiber distribution at higher fiber contents.

CONCLUSIONS OF THE STUDY

Based on the experimental work for M50 grade geopolymer concrete using hybrid fibers reported in the study, the following conclusions are drawn: Geopolymer concrete can be widely used in the manufacture of precast structures. It can be used in areas where faster strength achievement is needed. Fiber-reinforced geopolymer concrete eliminates the use of cement in concrete and helps to prevent global warming and to utilize fly ash effectively. Higher concentration of sodium hydroxide solution results in high compressive strength in the case of glass fiber, steel fiber, and a combination of fibers-based geopolymer concrete. Higher the ratio of sodium silicate to sodium hydroxide ratio by mass, the higher the compressive strength for glass fiber, steel fibre, and a combination of fibers-based geopolymer concrete. The compressive strength due to ambient curing for a combination of fibres-based geopolymer concrete does not depend on time period. The additions of super plasticizers are taken in different ratios, 2% of superplasticizers get the best results for compressive strength. Super plasticizer % is taken in a limit if it exceeds the limit, then automatically the compressive strength decreases. It was observed that the maximum strength using steel fibers was obtained at 0.3% and further it was observed to be decreasing. Similarly it was observed that in the case of glass fiber-based geopolymer concrete, the maximum strength was obtained at 0.4% and further it was observed to be decreasing. The strength achieved for the geopolymer concrete using hybrid fibers in different percentages has a considerable effect on the increase in the strength. The addition of GGBS in the combination of fibers has



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considerably reduced the setting time and the use of superplasticizers beyond the limit has a considerable effect on the strength of geopolymer concrete based on a combination of fibers.

Scope for Further Studies

The scope of this study is focused on the properties of geopolymer concrete with crimped steel and glass fiber as hybrid fibers. Six volume percentages of crimped steel and glass fiber are utilized to investigate the influence properties of concrete. The scope and limitations of this study are: The cement can be replaced by fly ash and GGBS in different proportions for higher strength achievement for M50 grade concrete mix. Different other types of fibres can be utilized to determine the strength parameters in different proportions

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Table 1: Chemical Composition of Fly Ash

S.NO	Composition percent by mass	Result
1.	SiO ₂ +Al ₂ O ₃ +Fe ₂ O ₃	94.66
2	SiO ₂	60.78
3.	MgO	0.94
4.	Total sulphur as SO ₃	0.12
5	Loss on ignition	0.88

Table 2: Chemical Composition of GGBS

S.No	Composition percent by mass	Result
1	CaO	30-50%
2	SiO ₂	28-38%
3	Al ₂ O ₃	8-24%
4	MgO	1-18%
5	MnO	0.68%
6	TiO ₂	0.58%
7	K ₂ O	0.37%

Table 3: Properties of Glass Fiber of Glass Fiber

Description	Result
Density	2.5
Young's modulus (Gpa)	70
Tensile strength (MPa)	2000 -3500
Elongation at break (%)	2.5

Table 4: Properties of Crimped Steel Fiber

Description	Result
Length	6cm
Thickness	1mm
Tensile strength (mpa)	421-800





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Elongation of break	1.62
Diameter (mm)	0.8-1.2mm
Density (g/cm ³)	1.47
Young's modulus (Gpa)	21-72
Aspect ratio	60

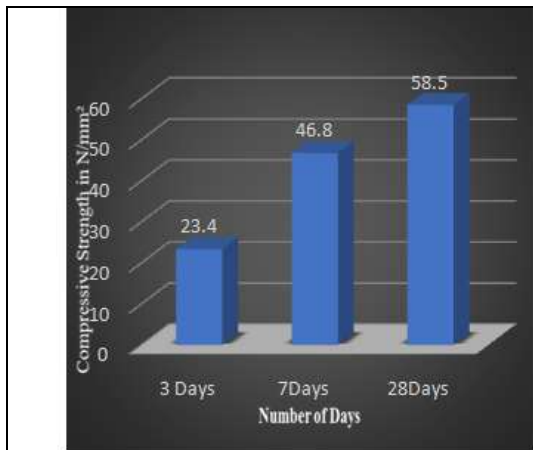


Fig 1: Compressive strength of Plain GPC

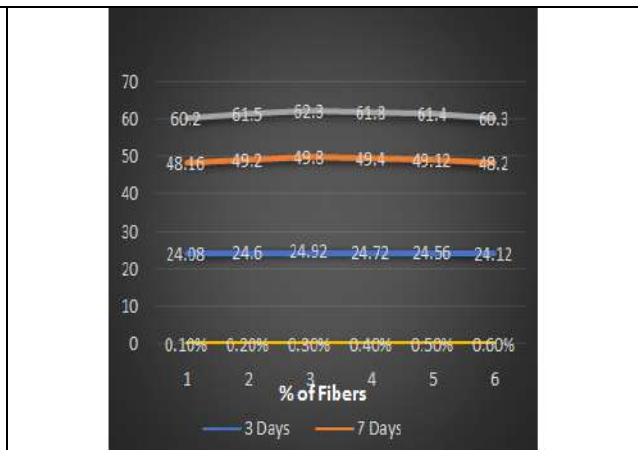


Fig 2: Compressive strength of M50 cubes using Steel fibres

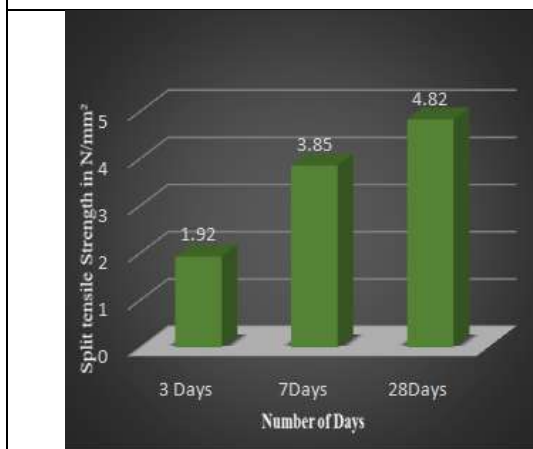


Fig 3: Split Tensile strength of Plain GPC

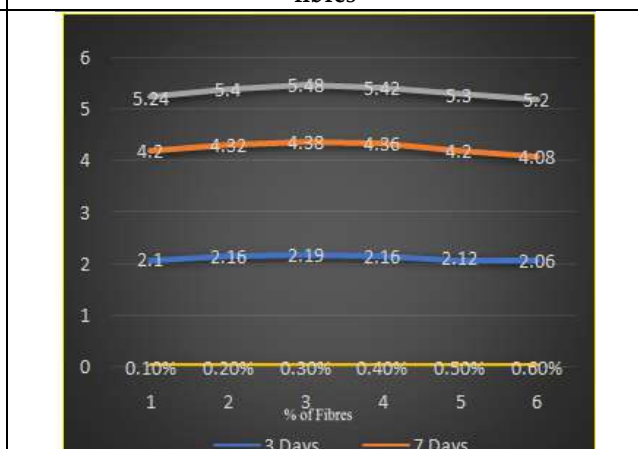


Fig 4: Split Tensile strength of M50 Cylinders using Steel fibres





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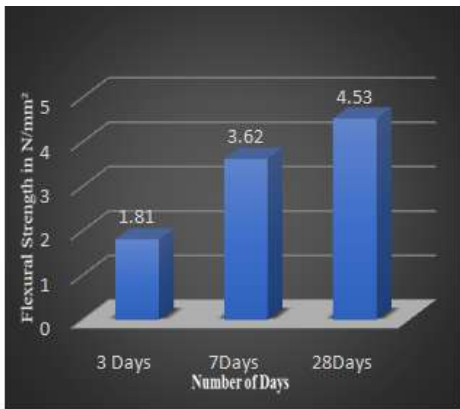


Fig 5: Flexural strength of Plain GPC

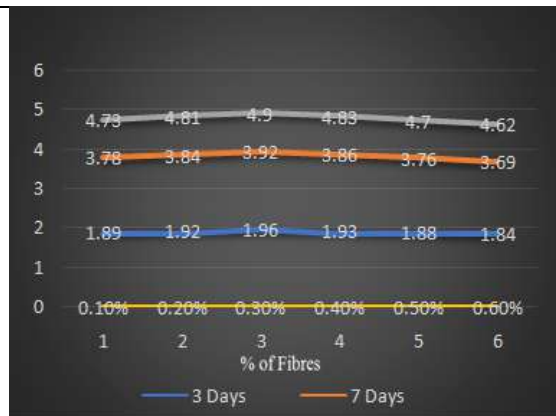


Fig 6: Flexural strength of M50 Prisms using Steel fibres





A Hybrid Method of Cloud File Storage Password Hashing using R3SKT Algorithm

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ABSTRACT

A network of remote file servers that are hosted online is used for cloud computing file storage. Without using local servers or personal computers, the cloud can store, manage, and process enormous quantities of files. How to safeguard this private data is one of the most worrying issues. The most popular strategies for cracking passwords in cryptanalysis are a dictionary attack and a brute force attack. Responsible for shielding the passwords from dictionary or brute force attacks and also strengthening the password hashing mechanism needed. Most of the hashing algorithms were attacked. In this solution, we tried a R3SKT algorithm for protecting passwords on cloud file storage. The algorithm was developed based on a dynamic selection of sub-algorithms, and different types of salting were used, like DNA nucleotide sequence. A dynamic selection of sub-algorithms was processed based on the attributes of the password, like size and character values. The newly created algorithm did not have any collisions. Every sub-algorithm was processed after a specific idea was used.

Keywords: Password Hashing, DNA Nucleotide Salting, Password Strengthen, Reverse Rail fence, Knights tour, Reverse Spiral, Repositioning bits, etc.,

INTRODUCTION

The well-organized rapidly developing technology that is gaining popularity is cloud computing. Cloud file storage is a technique for storing and retrieving data in the cloud which provides servers and apps with access to data via shared file systems. The benefits of cloud storage include respected storage, resources that are available when required minimal cost, simple storage administration, and easy user maintenance. Users won't have access to their



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files in the cloud because the data is kept in geographically dispersed, differently situated data centres. For controlling the user's authorization over their cloud-stored data, adequate policies and access control approaches are required. The cloud service provider sets these limitations, which must only permit authorized users of the file to access their data. In order to preserve the confidentiality of the cloud-stored file, certain control over access and protection systems are required. Different kinds (Figure 1) of users use the drive storage; they aren't aware they are on a secure platform. Some of the apps and websites are not truly secure in terms of their password policies. Tag along their credentials, create time, and use upper-case letters, characters, and special characters. But, really, not the passwords are strong or not. All businesses should be extremely concerned about the security of their data across all of their accounts and subscriptions, especially as more delicate data kinds are produced and kept in cloud tenants. Due to the large variety of data storage providers accessible, the diverse secret management requirements across multiple applications, and the vastly different compliance and regulatory requirements depending on the type of data, multi-tenant cloud data security is complicated. In order to provide centralized encryption control and administration, encryption key management services can be employed centrally across a number of tenants, but they must be correctly deployed and configured. The development of migration strategies for accounts to utilize new encryption keys produced in a centralized key management service deployment as opposed to those used within a single account or subscription requires the assistance of security teams.

Through the help of the hash algorithm, a string can be transformed into a collection of random characters. Because it only has the ability to do encryption and lacks the necessary decryption key[10], it is also known as a one-way function or one-way encryption. It functions by taking input strings with any length and transforming them into a hash value, which is a string with a set length. To secure the authentication procedure, hash is frequently utilized. Adding or pretending an arbitrary number to the user's password before hashing is known as salted password hashing. An authentication is a process used to confirm that a piece of property is real, verifiable, and reliable. It also involves having a strong belief in the reliability of the transmission, message, or sender. It ensures that the user's input into the system should come from a reliable source[9]. The process of authentication is essential because it secures data from unauthorized users while also protecting it. It also keeps the data's integrity[5]. To aid in the authentication process and reduce the possibility that an attacker may corrupt data, algorithms and hashing techniques are required. The authentication process uses a variety of methods, such as hashing, including the authentication of the login (password), the authenticity of the authentication file, the storage of the password, the production of keys and pseudorandom numbers, the authentication of tokens on services in a distributed system, the authentication of digital signatures, etc.. Due to recent hacking and public disclosure of private data (User's passwords) from several high-profile companies, including LinkedIn, E-harmony, and Yahoo within the last five years, serious concerns have been raised about the security of both their authentication systems and the methods they use to store the passwords in their databases. The majority of database applications usually keep their passwords in database in plain text, which is an insufficient means of protection, particularly for apps that hold sensitive user data.

RELATED WORKS

Anuraj Singh's et al.[1]securing passwords using a dynamic password policy The generator algorithm uses four algorithms to generate a hash password. Some of the limitations were used in the generator policy, like character length between 8 and 20, avoiding bad characters, and using good characters. The generator algorithm avoids uniformity characters based on the threshold idea. Dynamic policy tried to generate without repeated passwords. In the end, PBKDF2 was used after around 10,000 iterations. This algorithm prevents brute force, rainbow tables, and dictionary attacks. **AmolBhalerao**[3] shows the web password hashing technique used: salted hashing, SHA256, SHA512, RipeMD, and WHIRLPOOL. They are using short salt and salt reuse with the SHA256 technique to create a hash password. Salt added before SHA256 attackers may not be able to access the passwords or prevent birthday attacks and dictionary attacks.





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Sutriman's et al.[7] password and salt combination scheme shows that dynamically created salt will get added in a password-mingled manner. Reverse the new arrangement of passwords. The salting is generated by random character generation. The data collected for testing is Splash Data's top 100 worst passwords. Tested using the Hashcat penetration testing tool and produced their cracking time of password. **Dr. Abdelrahman Karrar et al.**[11] swapping elements in the array algorithm shows a password with a salt rearrangement revision process. The algorithm generates salt and reverses it then. Rearrangement of the password given by the user after processing the rearrangement It will be given to the SHA384 cryptographic hash function. After processing the password, it will be converted to base64. **Katha Chanda's et al.**[14] password analysis mechanism checking policy has an entropy function. Entropy measures uncertainty, or a lesser chance of guessing. Entropy is measured in percentages. The score will be calculated on the basis of the length. Less than 6 no scores and scores above 4 are there. Scores 4, 6, 8, and 10, respectively, are their levels. The score 4 means a weak password. Based on the score and entropy, the percentage will be calculated. Above 85 percent, the password is considered a strong password. Between weak and strong will be treated as a fair password. **Pramod George Jose et al.**[13] The bit sequence of the password is employed to add salt to steganography as part in the password hashing process. Use the MSB-LSB rule to compute password hashes. In addition to an effective mask and cumulative mask being employed in the hash, other fixed sets of bit-based activities are derived from his work. Using the computed hash to compare the extracted hash to, and then the final hash 12.5% of the cover medium's capacity would be the payload capacity.

METHODOLOGY

The R3SKT (Figure 2) hashing algorithm makes a hash of the password through some techniques, as follows: The salting process [6] was processed based on the DNA sequence specified in developing time. In this work used rare fish's DNA sequence to mix as salt to the password. After completed the salting process password the reverse rail fence approach will get added to the password. The reverse rail fence is different ideology comparing to the old method of rail fence. After processed reverse rail fence the dynamic selection of the algorithm's calculations worked out based on length and ASCII characters values. The selection process under different three kinds of algorithms was used. All three algorithms are processed after the salted password. However, the order of the algorithm determines the dynamic selection calculation. Each and every algorithm having an end to that reverse rail fence process will be done. Finally, hash generated whether requirement based on the size result hash(64 bytes, 128 bytes).

Password Salting Technique & Reverse Rail Fence

Fixed DNA nucleotide sequence used as salt[4]. The rare fish's DNA Sequence as used in this algorithm as salt. Mix password with salt based on the Rail fence technique. Finally, the Reversal Rail Fence (RRF) algorithm will be used on the salted password[11].

Processing:

Salt : TCATACCCAAGAAGACTCGAGGCTGTA

 Password: Hello123

 Rail Fence:

 Hello123

 TCATACC

Step 2 follows the rail fence. So, the password will be changed into: HTeCIAIToA1C2C3

Step 3 follows the reversal rail fence. So the password will be changed into:

Split : HTeCIAIT oA1C2C3

Reverse: TIAICeTH 3C2C1Ao

RRF: 3TCI2ACICe1TAHo.

Algorithm 1: RRF

Input : Salted Password

Output : partial Hash Password





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```

Begin
//splits the string into two substrings
Split1= substring(password,0,(mid/2+1));
Split2= substring(password,(mid/2+1),n);
//reverse the split strings.
Rev1=reverse(Split1);
Rev2=reverse(Split2);
// do rail fence on the rev1 and rev 2 then combine.
Password=RailFence(rev2,rev1);
Return (password);
End

```

Dynamic Policy

A random generated number has been generated for the purpose of choosing three algorithms to use on the hash function[2]. The random generated number is calculated based on the password length and the individual character's value[1].

$$M = \prod_0^{L-1} \sqrt{C^2} \times L$$

L= password length

C = individual character's ASCII value

M= Multiplication factor

The resultant multiplication factor used in generating the unrepeatable three-digit number (0 to 2) The three-digit number divisible by three and the remainder stored in unrepeatable numbers were then used as the dynamic selector of the algorithms in the hash function. The algorithms are Reposition and Repeat (RaR), Reverse Spiral Bits (RSB), and Knight Tour (KT). The algorithms explained next to that.

Reposition and Repeat

The RaR algorithm processes the password in redundantly taking 8 copies and shuffles the characters in a calculative logic. In the algorithm, 2D arrays are created, and the column size is the size of the password and the row size is 8. The redundant password is placed in a calculative manner when the formulation is used in the algorithm. The formula uses prime numbers, iterative numbers, and remaining numbers for the purpose of creating the calculated place value. Finally one time pad based the characters were converted into the results.

Algorithm 2: RaR

Input : Partial Hash Password

Output : Partial Hash Password

Begin

```

    pf=nextPrime(L+3);
    remain = L-1;
    for i=0 to 8
        forj=0 to 8
            iteration++;
            pos[i][j]=(pf * (iteration+j) * remain2) mod L;
            temp+=pos[i][j]
            remain--;
        pf=nextPrime(pf+3);
    endj

```





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```

    endi
    result = RRF(temp);
    result = OTP(result);
    return(result);
end

```

Reverse Spiral Bits(RSB)

The RSB algorithm processes the password in reverse spiral order, taking bits. The password has to be converted into binary bits after being placed into a 2D array with 7 columns and the password length is the same as the row size. Converted bits are placed in character-wise rows of 7 bits. A spiral order of traversal will follow to collect bits stored in memory. Then memory will get reversed to do the process of a reverse spiral. Finally, one-time pad-based characters were converted into the results.

Algorithm 3: RSB

```

Input : Partial Hash Password
Output : Partial Hash Password
Begin
    bits=convertintobits(password);
    matrix=plotbits(bits);
    temp=spiral(matrix);//process the spiral Order traversal on the bits
    temp1= reverse(temp);
result = RRF(temp1);
    result = OTP(result);
    return(result);
end

```

Knight Tour

Steps involved in KT algorithm are, Even the length of the password into 5 divisibility terms. Convert the password into binary bits. Stored the bits into the rectangular array (5 rows and 7 columns). Traversal happens in the array in Chess Knight Moves likewise the bits read and store into the memory. Same above steps follow on the remaining bits. Return the result as converted into 64 base fixed One Time Pad(OTP).

Algorithm 4: KT

```

Input : Partial Hash Password
Output : Partial Hash Password
Begin
password+="ATGC";
len=(password.length()/5)*5;
password=substring(password,0,len);
streambit=convertbits(password);
skt[][]=knightPositionreturn() //knight moving position Array
fori=0 to len(streambit) step 35:
    for j=0 to 5:
        for k=0 to 7:
            t+=""+streambit.charAt(i+skt[j][k]);
        end for k
    end for j
end for i
result = RRF(temp1);
    result = OTP(result);
    return(result);

```





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end

Result Hash

Steps involved in the Hash algorithm are, Convert the password into binary bits. Fix the base on a one-time pad for conversion of 6 bit characters. Iterate every 6 bits converted into base one time pad conversion and give the result password. Finally the resulting hash to be taken middle into 64 or 128 characters.(it may vary depending on the need of user memory requirements).

Algorithm 5: RH

Input : Partial Hash Password

Output : Final Hash Password

Begin

```
base="ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789~#"
rawbits= convertbits(password)
```

```
for i=0 to rawbits.length step 6
```

```
  if((i+6)<rawbits.length)
```

```
    temp=substring(rawbits,i,i+6)
```

```
  else
```

```
    temp= substring(rawbits,i,end)
```

```
  end if
```

```
  hash+=temp
```

```
end for
```

```
final Hash = substring(hash,middle-32,middle+32)
```

end

Final outcome of the algorithm gives a hash value. The hash values may vary depending on the attributes of the password. The attributes are length & character values. The Needed hash must be 64 characters. So, that the hash value middle 64 characters has been picked as a final password.

RESULTS AND DISCUSSION

In this research, a method that creates hashes based on the length and ASCII values of the characters has been created. The approach operates quickly, as determined by our computation of its time complexity. It will be difficult for the attacker to guess the password because the technique generates a value that can be hashed. By including these various characters, can able increase the password's complexity and make it harder for hackers to decipher. This hashing is intended for protecting websites or applications that are currently in use but are susceptible to many types of attacks, including dictionary, rainbow table, and brute-force attacks. Even if the attacker has gained access to the server and the database, using an upgraded hashing method will make it more difficult to crack the password. The algorithm tested (Table 1) in Intel(R) Core(TM) i3-2100 CPU @ 3.10GHz processor with windows 11 pro. But, the servers having 32, 16 cores this processor having 2 cores only. That's why time taken for processing. There are 3,91,519 password were tested. Passwords are taken from github 10 million user password lists. No collision occurred in the testing of the hash algorithm. The testing process taken under passwords is in numbers, characters and combinational mode. This algorithm gives better results in a mixed mode which is in use of characters and numbers in password and also mixed in special characters in password than better.

CONCLUSION AND FUTURE WORK

With the help of this Dynamic password policy, treated passwords in the different way protected from many types of attacks, including dictionary, rainbow table, and brute-force attacks. A password that is more secure than one that has been hashed using an improved hashing algorithm (such as PBKDF-2, Bcrypt, MD5, etc.), which makes it harder





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to crack even in cases when an attacker has gained access to the server and database. The password hashing will give better results when more number of rounds adds into the algorithm. Future work of this algorithm may be adding number of rounds altering small corrections in between algorithms.

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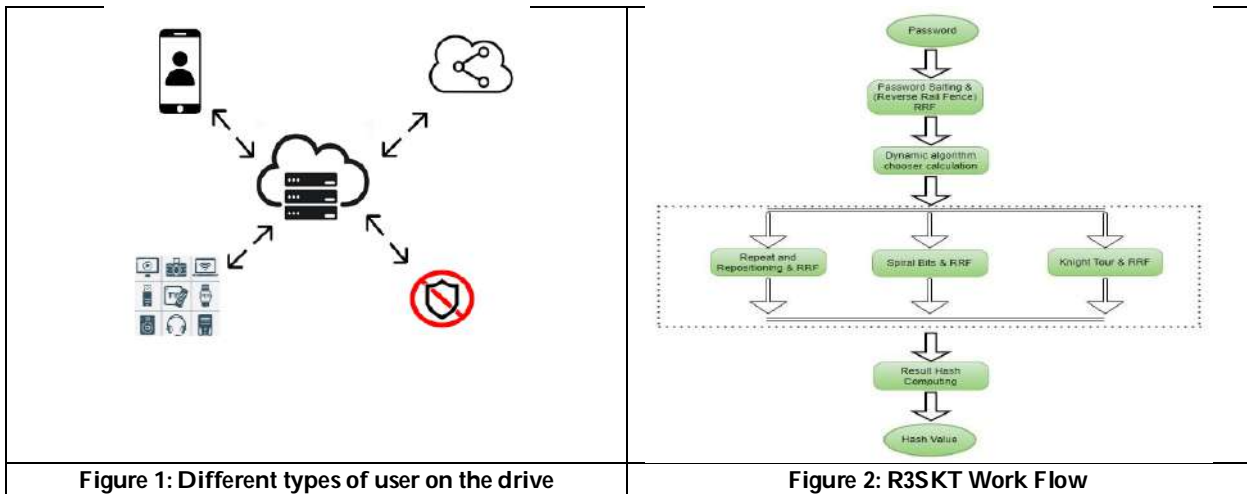
Table 1 : Comparison of other Hashing Algorithm with Time

Algorithms	R3SKT (sec)	MD5 (sec)	Salted MD5 (sec)	PBKDF2 (sec)	BCRYPT (sec)
10 Characters (password)	0.110	0.63	0.112	0.203	0.487
20 Characters (password)	0.141	0.78	0.169	0.216	0.523
Salted	Yes	No	Yes	Yes	Yes
Collision Occurrence	No	Yes	Yes	No	No





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Implementation of Time Series Stochastic Modelling for Pulses Production in India

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ABSTRACT

This study investigates the implementation of time series stochastic modelling for pulses production in India, using the production data for the period from 1975 to 2022. The article deals with trends and future projections of pulse production in India utilizing ARIMA (Auto-Regressive Integrated Moving Average) models. ARIMA (0,1,1) was chosen based on the estimates of the Box-Ljung Q statistics, Root Mean Square Error (RMSE), Mean Absolute Percentage Error (MAPE), Normalized BIC, and Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF). The production of pulses in India is expected to increase from 27.69 million tonnes in 2022 to 33.70 tonnes in 2030, according to the selected model.

Keywords: ARIMA, BIC, Forecasting, MAPE, Pulses Production, RMSE.

2010 Mathematics Subject Classifications

60: Probability theory and stochastic processes

62: Statistics

INTRODUCTION

India, a nation with a rich agricultural heritage, stands as one of the world's largest producers of pulses. Pulses, comprising lentils, beans, peas, and chickpeas, play a vital role in the Indian diet, offering a significant source of protein, fiber, and essential nutrients. The production of pulses in India is not just a matter of food security but also of economic importance, providing livelihoods to millions of farmers. Over the years, India has made concerted efforts to enhance pulse production through advancements in agricultural practices, policy interventions, and the adoption of high-yielding varieties. Despite these efforts, the sector continues to face challenges such as climate

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variability, pest infestations, and the need for improved storage and distribution systems. This article delves into the current state of pulse production in India, examining the factors driving its growth, the hurdles it encounters, and the strategies being employed to ensure its sustainable development. In recent years, the Indian government has launched several initiatives to boost pulse production and achieve self-sufficiency. The National Food Security Mission (NFSM) has been instrumental in promoting pulse cultivation through financial incentives, subsidies for seeds and fertilizers, and the dissemination of modern farming techniques. Additionally, the Minimum Support Price (MSP) scheme aims to ensure fair prices for farmers, encouraging them to allocate more land to pulse crops. Advances in agricultural research have led to the development of pest-resistant and drought-tolerant pulse varieties, further enhancing productivity. However, the sector still grapples with post-harvest losses due to inadequate storage facilities and market linkages. Addressing these challenges requires a multi-faceted approach, including strengthening the supply chain, improving infrastructure, and fostering public-private partnerships. By overcoming these obstacles, India can not only secure its domestic pulse requirements but also become a leading exporter, contributing to global food security. The health benefits of pulses and production states are shown in Figure 1.

MATERIAL AND METHODS

The current behavior of the variable under investigation is described by the ARIMA (Auto Regressive Integrated Moving Average) model in terms of linear relationships with its historical values. All that is needed for this extrapolation method is historical time series data for the variable being studied. The main purpose of ARIMA models is to forecast the associated variable. ARIMA residual autocorrelations were measured by Box and Pierce (1970). Slutsky (1973) applied Moving Average (MA) model. As described by Akaike (1983), the stationary time series is defined as being bounded by the same integer. Statistically independent and normally distributed residuals were significant features of stochastic time-series ARIMA models (Alan Pankratz, 1983) which were widely used to analyze time series data. Vishwajith et al. (2014) forecasted time series modeling and forecasting of pulses production in India with annual data from 2007 to 2015. Gagan Kumar (2016) developed and fitted forecast ARIMA (1,1,1) and ARIMA (1,1,1) model during 2014 to 2018 for forecasting production and area under cultivation for pulses in India using ARIMA model for the period from 1950-51 to 2013-14. Abhiram Dash and Subrat Kumar Mahapatra (2017) analysed and fitted ARIMA model for yield forecasting of important pulse crops of Odisha, India over the period 1971-72 to 2006-07 and 2007-08 to 2015-16. Mwangi Esther, N and Wangui Magdaline, N (2017) found that ARIMA (1,1,2) model as an appropriate to ARIMA Modeling to forecast pulses production in Kenya over the period 1961 to 2012. Pushpa M. Savadatti (2017) forecasted Trend and forecasting analysis of area, production and productivity of pulses in India with annual data from 1949-50 to 2015-16 and forecasted for the year from 2016-17 to 2020-21. Abhiram Dash et al. (2020) in their empirical study showed that ARIMA (0,1,1) is the appropriate model for forecasting of rabi pulse production in Odisha (India) by using Autoregressive Integrated Moving Average (ARIMA) technique for the period 1971-72 to 2015-16 forecasted model up to 2018-19. Jai Sankar and Pushpa (2020) considered ARIMA (0,1,1) model for stochastic forecasting analysis for peanut (*Arachis hypogaea*) production in India during the years from 1950-2017. Yashpal Singh Raghav et al. (2022) forecasted time series modeling and forecasting of pulses production in India with annual data from 1961 to 2015. Jai Sankar and Pushpa (2023) calculated ARIMA (0,1,2) model for implementation of stochastic time series forecasting ARIMA model for *Hordeum vulgare* production in India during the years from 1960 to 2020. Supriya et al. (2023) identified to fit ARIMA model for modeling and forecasting of lentil production in India and its instability for the period of 1970 to 2019 and forecasted up to 2029. Vishwajith et al. (2023) forecasted modeling and forecasting of lentil in India with annual data from 1970 to 2009 and forecasted model up to 2020. Sneha S. Ketali et al. (2024) identified to fit ARIMA model towards *atmanirbharta* (self-reliance) in the production of pulse crops in India: A situational analysis of future demand and supply for the period of 1950-51 to 2017-18 and forecasted up to 2018-19 to 2030-31.

In this study, a four-step ARIMA model was used, consisting of identification, estimation, diagnostic checking, and forecasting. Model parameters were considered to fit the ARIMA models.

AR process of order (p) is, $Y_t = \mu + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \dots + \phi_p Y_{t-p} + \varepsilon_t$;





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MA process of order (q) is, $Y_t = \mu - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-q} + \varepsilon_t$; and

ARIMA process of order (p, d, q) is,

$$Y_t = \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \dots + \phi_p Y_{t-p} + \mu - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-q} + \varepsilon_t$$

where Y_t - PulsesProduction, ε_t 's - independently and normally distributed with zero mean and constant variance σ^2 for $t = 1, 2, \dots, n$; d - the fraction differenced while interpreting AR and MA, and ϕ 's and θ 's - coefficients to be valued.

Trend Fitting

The Box-Ljung Q statistics was used to convert the non-stationary data into stationarity data and also to validate the adequacy for the residuals. For evaluating the adequacy of AR, MA and ARIMA processes, a range of reliability statistics like R squared, Stationary R squared, RMSE, MAPE and BIC were applied. The reliability statistics viz. RMSE, MAPE, BIC and Q statistics were computed as below:

$$RMSE = \left[\frac{1}{n} \sum_{i=1}^n (Y_i - \hat{Y}_i)^2 \right]^{1/2} \text{ and}$$

$$MAPE = \frac{1}{n} \sum_{i=1}^n \left| \frac{Y_i - \hat{Y}_i}{Y_i} \right|$$

$$BIC(p, q) = \ln v^*(p, q) + (p + q) \left[\frac{\ln(n)}{n} \right]$$

where p and q - order of AR and MA processes; n - number of observations; and v^* - approximate of white noise variance σ^2 .

$$Q = \frac{n(n+2) \sum_{i=1}^k rk^2}{(n-k)}$$

where n - number of residuals and rk - residuals autocorrelation at lag k.

In this analysis, the data on Pulsesproduction in India were collected from the Annual Report Agricultural Statistics at a Glance 2022, Government of India for the period from 1975 to 2022 (Table 1) and were applied to fit the ARIMA model to predict the future production.

RESULTS AND DISCUSSION

In this analysis, to fit an ARIMA model, the process for any variable involves four steps: identification, estimation, diagnostic and forecasting. ARIMA (p,d,q) is steady to make certain stationarity through reading the graph or time plot of the given data. Figure 2 suggests that the data is non-stationary. The autocorrelation and partial autocorrelation coefficients of various orders of Y_t are calculated (Table 2). The graphs of ACF and PACF are produced (Figure 3). The models and corresponding BIC values are specified (Table 3). The value of normalized BIC is 1.382 and R squared value is 0.838 in the most appropriate model for pulsesproduction is ARIMA(0,1,1) as this model has the lowest BIC value.

Model Estimation: Model parameters were found and accounted (Table 4 and Table 5). The model verification is concerned with examining the residuals of the model to progress on the chosen ARIMA (p,d,q). This is done through validating the autocorrelations and partial autocorrelations of the residuals of various orders, up to 32 lags were considered and the same along with their significance which is checked by Box-Ljung test are given (Table 6). This proves that the chosen ARIMA model is a suitable model.





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The ACF and PACF of the residuals are specified (Figure 4) and also indicated 'good fit' for the selected ARIMA model of the pulses production data is

$$Y_t = \mu - \theta_1 \varepsilon_{t-1} + \varepsilon_t$$

$$Y_t = -43.350 + 0.680\varepsilon_{t-1} + \varepsilon_t$$

The forecasted value of pulses production (quantity in million tonnes) for the years 2023 through 2030 respectively is given by 27.06, 27.94, 28.85, 29.77, 30.72, 31.69, 32.69 and 33.70 in Table 7. We calculated significant measures of the forecasts' accuracy for the sample period in order to evaluate the fit of an ARIMA (p,d,q) model. This measure shows that the forecasting inaccuracy is low. Figure 5 indicates that the actual and forecasted value of pulses production data with 95% confidence limits.

CONCLUSION

The results of this study give an indication on future pulses production in India, which can be taken into consideration for future policy creation and the formulation of new strategies for increasing and supporting pulses production in India. The most suitable ARIMA model for data forecasting on pulses production was found to be ARIMA (0,1,1). It can be found that forecasted production would increase from 27.69 million tonnes in 2022 to 33.70 million tonnes in 2030 in India based on time series data from 1975 to 2022 on pulses production.

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Table 1 - Actual Pulses Production (million tones) in India

Year	Production	Year	Production	Year	Production
1975	10.02	1991	14.26	2007	14.20
1976	13.04	1992	12.02	2008	14.76
1977	11.36	1993	12.82	2009	14.57
1978	11.97	1994	13.30	2010	14.66
1979	12.18	1995	14.04	2011	18.24
1980	8.57	1996	12.31	2012	17.09
1981	10.63	1997	14.15	2013	18.34
1982	11.51	1998	12.97	2014	19.25
1983	11.86	1999	14.91	2015	17.15
1984	12.89	2000	13.42	2016	16.32
1985	11.96	2001	11.08	2017	23.13
1986	13.36	2002	13.37	2018	25.42
1987	11.71	2003	11.13	2019	22.08
1988	10.96	2004	14.91	2020	23.03
1989	13.85	2005	13.13	2021	25.46
1990	12.86	2006	13.38	2022	27.69

Table 2 - ACF and PACF of Pulses Production

Lag	AC	Std. Error (white noise)	Box-Ljung Statistic	PAC	Std. Error	Lag	AC	Std. Error (white noise)	Box-Ljung Statistic	PAC	Std. Error
	Value	Df	Sig. (Chi-Square Approx.)	Value	Df		Value	Df	Sig. (Chi-Square Approx.)	Value	Df
1	0.777	0.140	30.859	0.777	0.144	17	-0.071	0.114	125.322	-0.066	0.144
2	0.670	0.138	54.252	0.165	0.144	18	-0.050	0.112	125.522	0.055	0.144
3	0.615	0.137	74.447	0.136	0.144	19	-0.097	0.110	126.308	-0.017	0.144
4	0.565	0.135	91.879	0.060	0.144	20	-0.065	0.108	126.673	0.072	0.144
5	0.456	0.134	103.475	-0.135	0.144	21	-0.070	0.106	127.109	-0.030	0.144
6	0.323	0.132	109.449	-0.185	0.144	22	-0.050	0.104	127.343	0.031	0.144
7	0.319	0.131	115.401	0.166	0.144	23	-0.040	0.102	127.494	-0.013	0.144
8	0.269	0.129	119.758	-0.026	0.144	24	-0.096	0.100	128.419	-0.192	0.144
9	0.206	0.127	122.368	-0.017	0.144	25	-0.096	0.098	129.390	0.033	0.144
10	0.151	0.126	123.816	-0.007	0.144	26	-0.112	0.096	130.765	-0.035	0.144





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11	0.097	0.124	124.430	-0.105	0.144	27	-0.115	0.094	132.278	0.001	0.144
12	0.029	0.122	124.485	-0.138	0.144	28	-0.126	0.091	134.177	0.038	0.144
13	0.040	0.121	124.595	0.213	0.144	29	-0.173	0.089	137.940	-0.139	0.144
14	-0.006	0.119	124.597	-0.099	0.144	30	-0.191	0.087	142.821	-0.099	0.144
15	-0.029	0.117	124.659	0.019	0.144	31	-0.188	0.084	147.824	0.034	0.144
16	-0.060	0.115	124.927	-0.019	0.144	32	-0.214	0.082	154.723	-0.021	0.144

Table 3 - BIC values of ARIMA(p,d,q)

ARIMA (p,d,q)	BIC Values
0,1,0	1.597
0,1,1	1.382
0,1,2	1.484
1,1,0	1.566
1,1,1	1.486
1,1,2	1.528
2,1,0	1.544
2,1,1	1.555
2,1,2	1.538
3,1,0	1.575
3,1,1	1.647
3,1,2	1.728

Table 4 - Estimated AR Model of Pulses Production

	Estimate	SE	t	Sig.
Constant	-43.350	14.071	-3.223	0.002
MA 1	0.680	0.122	5.567	0.000

Table 5 - Estimated AR Model Fit Statistics

ARIMA (p,d,q)	Stationary	R ²	R ²	RMSE	MAPE	MaxAPE	MAE	MaxAE	Normalized BIC
0,1,0	0.022	0.778	2.048	11.324	41.544	1.601	6.031	1.597	
0,1,1	0.290	0.838	1.765	9.348	33.976	1.343	4.233	1.382	
0,1,2	0.292	0.839	1.783	9.417	34.132	1.351	4.056	1.484	
1,1,0	0.146	0.806	1.935	10.014	39.476	1.463	5.445	1.566	
1,1,1	0.291	0.839	1.784	9.395	33.992	1.349	4.081	1.486	
1,1,2	0.334	0.849	1.749	9.473	30.823	1.360	4.266	1.528	
2,1,0	0.248	0.829	1.837	9.685	35.623	1.385	4.274	1.544	
2,1,1	0.316	0.844	1.773	9.421	33.573	1.326	3.731	1.555	
2,1,2	0.395	0.863	1.687	9.479	32.201	1.314	3.290	1.538	
3,1,0	0.302	0.841	1.791	9.364	38.537	1.304	3.807	1.575	
3,1,1	0.326	0.847	1.782	9.371	34.568	1.318	3.590	1.647	
3,1,2	0.343	0.851	1.781	9.422	30.957	1.338	3.942	1.728	





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Table - 6 Residual of ACF and PACF of Pulses Production

Lag	ACF		PACF		Lag	ACF		PACF	
	Mean	SE	Mean	SE		Mean	SE	Mean	SE
1	0.037	0.146	0.037	0.146	17	-0.251	0.168	-0.206	0.146
2	-0.151	0.146	-0.153	0.146	18	0.020	0.175	-0.051	0.146
3	0.002	0.149	0.015	0.146	19	-0.134	0.176	-0.145	0.146
4	0.091	0.149	0.068	0.146	20	-0.061	0.178	-0.125	0.146
5	0.154	0.151	0.154	0.146	21	-0.070	0.178	0.005	0.146
6	0.016	0.154	0.029	0.146	22	-0.064	0.179	-0.040	0.146
7	0.163	0.154	0.216	0.146	23	0.080	0.179	0.202	0.146
8	0.013	0.158	-0.001	0.146	24	-0.124	0.180	0.006	0.146
9	0.020	0.158	0.062	0.146	25	-0.153	0.182	0.022	0.146
10	0.014	0.158	-0.023	0.146	26	-0.081	0.184	-0.063	0.146
11	-0.062	0.158	-0.092	0.146	27	-0.012	0.185	0.005	0.146
12	-0.162	0.158	-0.253	0.146	28	0.132	0.185	0.043	0.146
13	0.153	0.162	0.136	0.146	29	-0.013	0.187	0.009	0.146
14	-0.004	0.165	-0.158	0.146	30	-0.129	0.187	-0.080	0.146
15	-0.035	0.165	0.055	0.146	31	-0.053	0.189	-0.093	0.146
16	-0.147	0.165	-0.176	0.146	32	0.036	0.189	0.003	0.146

Table 7 - Forecast of Pulses Production

Year	Predicted	LCL	UCL
2023	27.06	23.55	30.57
2024	27.94	24.26	31.63
2025	28.85	24.99	32.70
2026	29.77	25.76	33.79
2027	30.72	26.55	34.89
2028	31.69	27.37	36.01
2029	32.69	28.22	37.15
2030	33.70	29.10	38.31

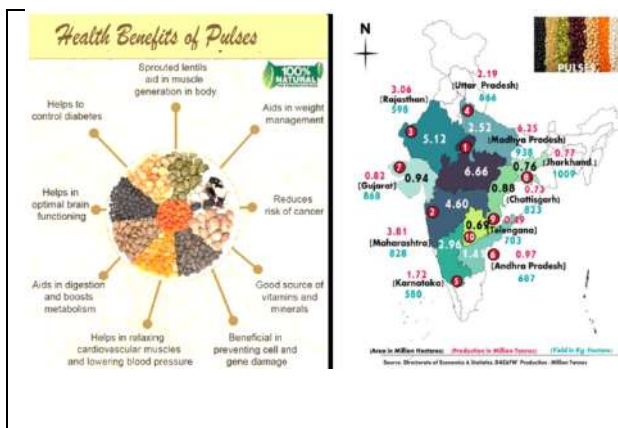


Figure 1- Health Benefits and India's Growing States of Pulses.

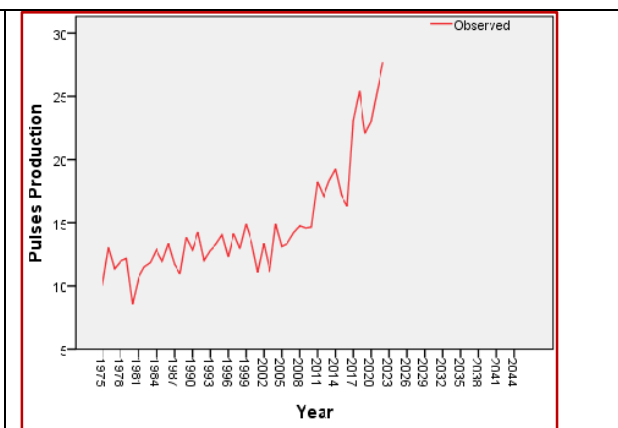


Figure 2 - Time plot of Pulses Production





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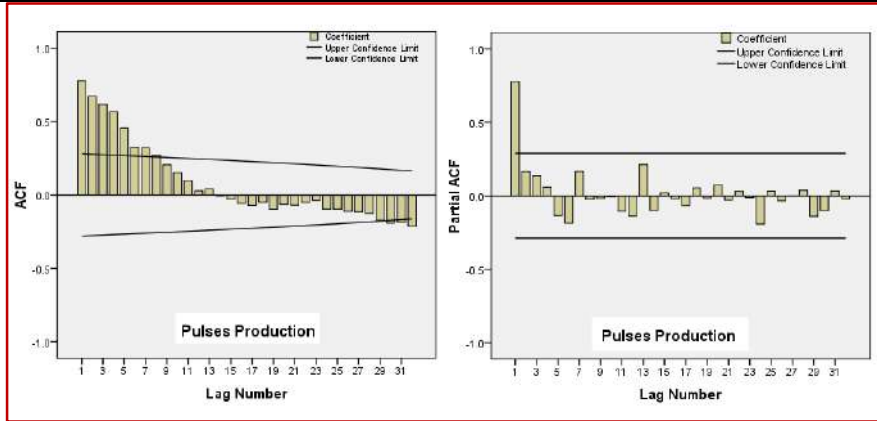


Figure 3 - ACF and PACF of differenced data

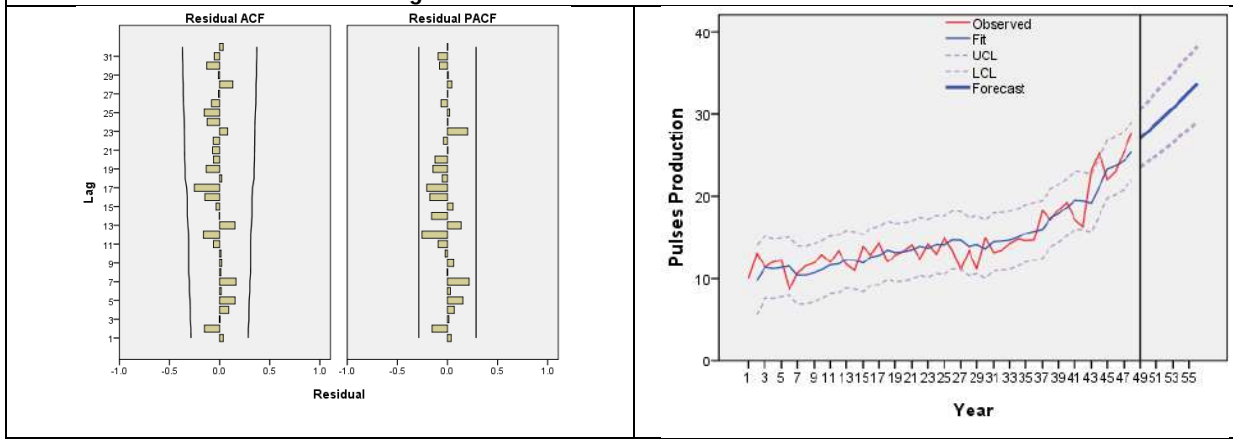


Figure 4 - Residuals of ACF and PACF

Figure 5 - Actual and Estimate of PulsesProduction





A Validated RP-HPLC Method for Vildagliptin in Bulk and Pharmaceutical Dosage Form

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ABSTRACT

A clear and concise, rapid and accurately vildagliptin can now be quantified using a reversed phase-high performance liquid chromatography (RP-HPLC) based analytical technique with UV. The C18 analytical column was used for the analysis. This mobile phase runs through binary mode at a flow rate of 1ml/min and is composed with buffer and acetonitrile solution in a 50:50 ratio. The analyte was detected at 206 nm, and linearity was achieved at concentrations between 20 and 80 µg/ml. Retention lasted for 2.664 minutes. Vildagliptin average recoveries were discovered to be between 99.2 and 99.8%. The analytical method was verified in accordance with ICH standards for the parameters having linearity, precision, accuracy, specificity, ruggedness, robustness, limit of detection and quantification. The created approach can be applied to the regular examination in vildagliptin in pharmaceutical and bulk dosage form.

Keywords: Vildagliptin, RP-HPLC, Method Development, Method Validation.





INTRODUCTION

Vildagliptin is a once-daily dipeptidyl peptidase 4 (DPP-4) inhibitor used in the management of type 2 diabetes mellitus. Vildagliptin (LAF237) is an orally active anti-hyperglycemic agent that selectively inhibits the dipeptidyl peptidase-4 (DPP-4) enzyme. It is used to manage type II diabetes mellitus, where GLP-1 secretion and insulinotropic effects are impaired. Its chemical formula $C_{17}H_{25}N_3O_2$ and IUPAC name is 1-[2-[(3-hydroxy-1-adamantyl) amino acetyl] pyrrolidine-2-carbonitrile. Molecular weight is 303.399g/mol. The primary mechanism of action of vildagliptin exerts its blood glucose-lowering effects by selectively inhibiting the dipeptidyl peptidase-4 i.e, (DPP-4), which is an enzyme that, upon release from the intestinal cells, rapidly truncates and inactivates GLP-1 and GIP. Oligopeptides are broken down by DPP-4 after the second amino acid from the N- terminal end. The half -lives of GLP-1 and GIP are markedly extended by the inhibition of DPP-4, resulting in higher quantities of active incretin hormones in the blood. Vildagliptins lowers fasting, postprandial and HbA1c levels of glucose. The alpha and beta cell glucose sensitivity is improved, and glucose dependent insulin secretion is also increased.

MATERIALS AND METHODS

Instrument

Shimadzu HPLC system with an SPD-20A detector with configurable wavelength, LC-20AD binary gradient pump, and SCL-20A system controller. Data were recorded and analysed using LC solutions software using a Rheodyne injector equipped with a 20-loop. An enable C18 column (250×4.6mm, 5µm particle) was used. Elite analytical balance is also used.

Reagents and pharmaceutical preparation

Acetonitrile is obtained from the Fisher Scientific and phosphate buffer of pH 6.8 was prepared by using HPLC grade water.

Vildagliptin (Drug substance): Sample was obtained as gift sample

Vildagliptin (Drug product): Vildaray

Preparation of mobile phase:

Preparation of buffer solution of pH 6.8

Dissolve 27.23grams of potassium dihydrogen phosphate and 0.896grams of sodium hydroxide using 1000ml HPLC grade water and adjust the pH 6.8 with sodium hydroxide and sonicate for 20minutes each three times and then filter through 0.2µm filter paper and degas.

Preparation of Acetonitrile: Acetonitrile was sonicated for 20mins each for 3 times. After sonication degassed, filtered the solution through 0.2µm membrane filter before purging into the HPLC system.

The mobile phase A consists of phosphate buffer 6.8 and mobile phase B consists of acetonitrile of HPLC grade. Both the mobile phase solutions were degasses and filter through 0.2µm membrane filter before purging into HPLC system.

Preparation of standard stock solution (1000µg/ml)

A standard drug solution of vildagliptin was prepared by adding 100mg of drug into 100ml volumetric flask and made upto the mark with buffer and solution mixture in the ratio of (50:50) to get a concentration of 1000µg/ml.

Preparation of working stock solution (100µg/ml)

From the above prepared standard stock solution 10ml of the sample was transferred to a 100ml volumetric flask and makeup to the mark with buffer and solution mixture in the ratio of (50:50) to get concentration of 100µg/ml.



**Varaprasada Rao et al.,****Preparation of sample solution**

The assay for the content in commercially available Vildagliptin tablets was performed with the developed chromatographic conditions and the results have reliability and also accuracy. The Vildagliptin tablets were weighed and their mean weight was determined and then the tablets are triturated to powder form. The tablet powder equivalent to 20mg was weighed and transferred into a volumetric flask. Now dissolve and dilute upto the mark by using the mobile phase (buffer and solution 50:50). Then the solution is filtered using the Whatman filter paper. Now from the filtrate appropriate dilutions are made with the mobile phase to obtain 3.2µg, 4µg, 4.8µg for 80, 100, 120% respectively and then the final solution was filtered through 0.2µm Millipore filter and it was analysed by HPLC system.

Method development

After performing the various trails, it was discovered that the following conditions were ideal for the method development since they allowed for the observation of theoretical plates and a drug peak with less tailing. The optimized conditions are listed in Table 1 and optimized chromatogram in Figure 2.

Method Validation**System Suitability**

System appropriateness is used to determine whether the chromatographic system's resolution and repeatability are sufficient for analysis. The theoretical plate count must be at least 2,500 and the tailing factor must not be greater than 2. The Table 2 displays the outcomes.

Linearity

Take 10mg of vildagliptin in a 10ml volumetric flask and diluted with buffer upto mark. From the stock solution 1ml of sample was take and make upto the volume of 10ml in volumetric flask. The calibration curve was constructed by plotting absorbance and concentration of vildagliptin and the regression coefficient was calculated. The graph was plotted over different concentrations of 0, 20, 40, 60, 80 µg/ml. By plotting the absorbance data, a calibrated graph was created, and it was discovered that the final concentration was linear over the concentration ranges of 10-100 µg/ml. Calibration curve data is represented in Table and Figure 3.

Precision

Numerous measurements taken under identical analytical conditions are used to determine precision. The next step is to gauge how closely the data values are related to one another. In accordance with ICH criteria, the components of accuracy are repeatability (Intraday precision), intermediate precision, and system precision. The % RSD for the area of 6 injections was found to be less than 2. Hence the results obtained were found to be satisfactory. The results are shown in Table 4,5,6.

Accuracy

Recovery procedure or the external standard addition method was used to determine the approach's correctness. The pre-analyzed sample had the known standard amount added to it at three distinct levels: 80%, 100%, and 120%. There were three copies of each determination. The results were shown in the Table7. The percentage recovery of 80%, 100% and 120% was in between the 98% to 100%. hence the method was found to be accurate.

Robustness

The robustness of the approach was assessed by making small adjustments to the chromatographic settings, such as changing the mobile phase's composition, wavelength, and flow rate. Since there were no obvious alterations in the chromatograms, the established RP-HPLC method was found to be reliable. The results are shown in Table 8,9.

Ruggedness

According to the USP, ruggedness refers to the degree of reproducibility of results achieved under various circumstances, including those involving various laboratories, analyzers, instruments, environmental conditions,



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operators, and materials. The reproducibility of test results from lab to lab and analyst to analyst under typical, expected operational settings is measured by ruggedness. There were no marked variations in the chromatograms by changing in the analyst, and low % RSD was indicates that the method found to be rugged. The results are shown in Table 10.

Limit of Detection and Quantification

The lowest concentration of an analyte that an analytical procedure can consistently distinguish from background levels is known as the limit of detection (LOD). The lowest concentration is referred to as the limit of quantitation (LOQ) of the standard curve that can be measured with acceptable accuracy, precision, and variability. The results are shown in Table 11.

RESULTS

Table 2 :System parameters of Vildagliptin

Table 3:Calibration curve data for Vildagliptin

Fig. 3: Calibration curve data of Vildagliptin (Concentration Vs Absorbance) Intermediate precision (Inter day):

Table 4: Precision data of Vildagliptin at 40µg/ml

Table 5: Precision data of Vildagliptin at 60g/ml

Table 6: Precision data of Vildagliptin at 80µg/ml

Table 7: Accuracy of Vildagliptin

Table 8: Change in flowrate Robustness

Table 9: Change in wavelength Robustness

Table 10: Ruggedness

Table 11: LOD & LOQ

ASSAY

Table 12: Assay of Vildagliptin

DISCUSSION

The present work is based on RP-HPLC technique with UV detection was developed and validation for quantification of Vildagliptin. The analytical parameters chosen was based on physical and chemical properties of Vildagliptin. Based on teneligliptin system suitability parameters stationary phase was selected. The analytical parameters choosen was based on physical and chemical properties of teneligliptin. Thermosil C18 column was selected for separation of analyte based on evaluation parameters. Preliminary trails are carried out using different mobile phase composed of mixture of solvents. A mixture of buffer and solution of acetonitrile is taken in 60:40 was found to be ideal combination based on satisfactory system suitability parameters. Mobile phase flow rates ranged from 0.5-2 ml/min. Trials revealed that vildagliptin could be successfully eluted at a rate of 1ml/min. Vildagliptin standard solution was scanned between 200 and 350 nm to determine wavelength. The 206 nm detecting wavelength is chosen. According to ICH requirements, the devised method was validated, and it was discovered to be precise, easy to use, and trustworthy.

CONCLUSION

The developed reversed-phase high-performance liquid chromatography (RP-HPLC) method with UV detection offers a rapid and accurate means of quantifying vildagliptin. Employing a C18 analytical column and a mobile phase composed of a 50:50 ratio of buffer and acetonitrile, the method demonstrated robust performance with a flow



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rate of 1 ml/min. The achieved linearity within the concentration range of 20 to 80 µg/ml, coupled with a short retention time of 2.664 minutes, underscores the method's efficiency. Exceptional average recoveries ranging from 99.2 to 99.8% further validate the method's accuracy and reliability. The method's verification against ICH standards for various parameters, including linearity, precision, accuracy, specificity, ruggedness, robustness, limit of detection, and quantification, attests to its robustness and suitability for routine analysis. With these attributes, the developed RP-HPLC method stands as a valuable tool for the precise quantification of vildagliptin in both pharmaceutical and bulk dosage forms, facilitating efficient quality control in pharmaceutical applications.

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Table 1: Optimized Chromatographic conditions

Column	Enable C18G (250×4.6 mm i.d., 5μ), ODS Column
Flow rate	1.0ml/min
Mobile phase	potassium dihydrogen phosphate buffer pH 6.8 Acetonitrile (60:40)
Detector wavelength	206nm
Column temperature	Ambient
Injection volume	20μl
Run time	10mins
Retention time	2.664min

Table 2 :System parameters of Vildagliptin

Parameters	Vildagliptin
Retention time	2.664
Tailing factor	1.434
Theoretical plates	3326.4

Table 3:Calibration curve data for Vildagliptin

S.No.	Vildagliptin	
	Conc(μg/ml)	Peak area
1.	20	35613553
2.	40	41513465
3.	60	46302353
4.	80	52314382
5.	100	58203271





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Table 4: Precision data of Vildagliptin at 40µg/ml

S.No.	Vildagliptin		
	Conc(µg/ml)	Inter day Precision(area)	Intra day Precision (area)
1.	40	41513464	41213626
2.	40	40412352	41023515
3.	40	41321434	40212414
4.	40	41235216	41321424
5.	40	42103424	41310326
6.	40	41362123	41123142
Mean		41324669	41034075
SD		544764	418161
%RSD		1.3%	1.0%

Table 5: Precision data of Vildagliptin at 60g/ml

S.No.	Vildagliptin		
	Conc(µg/ml)	Interday precision	Intraday precision
1.	60	41513462	41361426
2.	60	41412354	41321422
3.	60	40162132	40142214
4.	60	41361428	42104146
5.	60	41512342	41042318
6.	60	40263232	41513466
Mean		41037492	41247332
SD		642373	646094
%RSD		1.5%	1.5%

Table 6: Precision data of Vildagliptin at 80µg/ml

S.No.	Vildagliptin		
	Conc(µg/ml)	Interday precision	Intraday precision
1.	80	51202354	51024514
2.	80	51623123	50212412
3.	80	50123424	51213424
4.	80	51362346	51321326
5.	80	51230426	50112412
6.	80	51526424	51283142
Mean		51178016	50861705
SD		542031	551741
%RSD		1.3%	1.0%

Table 7: Accuracy of Vildagliptin

%Spike level	Sample	Amount added (std)	Amount found (µg/ml)	% Recovery	Statistical parameters
80	40	32	31.68	99.1	Mean= 99.3 SD= 0.3214 %RSD= 0.32%
	40	32	31.91	99.7	
	40	32	31.76	99.2	
100	40	40	39.87	99.6	Mean=99.6 SD= 0.1154 %RSD= 0.11%
	40	40	39.92	99.8	
	40	40	39.86	99.6	





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120	40	48	47.93	99.8	Mean=99.7 SD= 0.1 %RSD= 0.10%
	40	48	47.90	99.7	
	40	48	47.82	99.6	

Table 8: Change in flowrate Robustness

S.No.	Vildagliptin		
	Change in Flowrate		
	0.9ml	1ml	1.1ml
1.	42332414	41543464	45104216
2.	43212302	41402353	45023212
3.	42302412	41313465	45223408
4.	42128636	41274563	45124356
5.	42642308	41821434	46042321
6.	42123464	41612122	46412136
Mean	42456923	41489567	45422275
SD	415528	205217	547684
%RSD	0.9%	0.5%	1.2%

Table 9: Change in wavelength Robustness

S.No.	Vildagliptin		
	Change in wavelength		
	205nm	206nm	207nm
1.	40201425	41513462	44274562
2.	42143624	41263452	45223468
3.	42104146	41710323	44312126
4.	42321628	41501242	44342432
5.	41765432	41324654	45102648
6.	41682136	40265178	44124232
Mean	41703065	41263052	44563245
SD	774187	513622	472173
%RSD	1.8%	1.2%	1.0%

Table 10: Ruggedness

S.No.	Vildagliptin	
	Change in analyst	
	Analyst-1	Analyst-2
1.	41489567	42123464
2.	41612122	42642308
3.	41274563	42128636
4.	41513464	42332414
5.	41402356	42302412
6.	41313465	43212302
Mean	41489657	42456824
SD	205214	415528
%RSD	0.5%	0.9%





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Table 11: LOD & LOQ

Drug	LOD($\mu\text{g/ml}$)	LOQ($\mu\text{g/ml}$)
Vildagliptin	0.02 $\mu\text{g/ml}$	0.07 $\mu\text{g/ml}$

Table 12: Assay of Vildagliptin

Tablet	Drug	Labelled claim(mg)	Amount found(mg)	% Recovery
Vildaray	Vildagliptin	50mg	48.92	98.62%

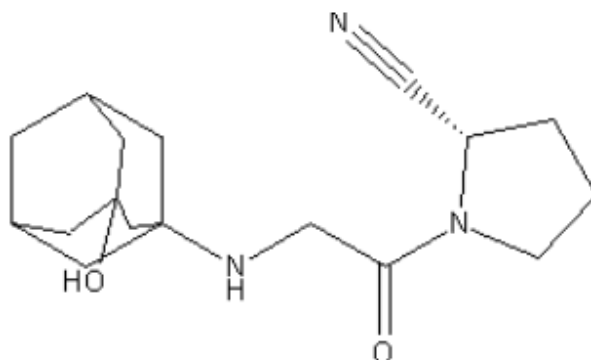


Fig.1: Structure of Vildagliptin

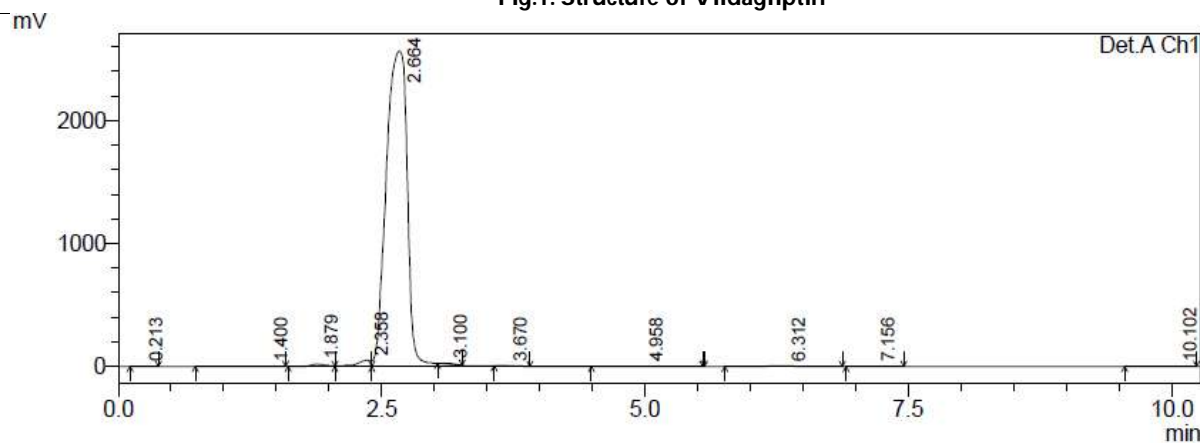


Fig 2: Optimized Chromatogram





Impact of Smart Grid on Environment

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ABSTRACT

With the increase in severe energy shortage & global warming context, it becomes necessary to look towards cleaner energy sources. Incorporating clean sources in the existing grid will result in less carbon emissions & help in proceeding with our steps towards sustainable development. The implementation of Smart Grids in developing nations like India will act as a benchmark in global carbon footprint reduction. This paper highlights the contribution of the smart grid in achieving sustainability and curbing climate change.

Keywords: Smart Grid, Clean Energy, Sustainability

INTRODUCTION

All around the world utility companies are looking towards an efficient solution to address the power sector issues. The current electrical grid system uses fossil fuels-based power-generating sources which is one of the root causes of global warming. Due to rapid industrialization, urbanization & increment in population energy demand in increased in residential, commercial, industrial & transportation sectors. India is having more dependency on fossil fuels for fulfilling energy demands which lead to degradation of the environment, air pollution & greenhouse gas emissions. With the increase in population and power demand the efficient and effective usage of the electrical grid is required, which is possible with smart grid(SG). An SG is a kind of grid embedded with modern technologies that enable 2-way communication technology. As they incorporate the





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renewable energy system they are sustainable in nature working in an environment-friendly manner and economically. In the last 10 years, the electricity grid has been smartly developed with several initiatives of the government of India. Smart Grid has extensive features like. Advanced Metering Infrastructure, Distributed generation, Smart Home Automation, Demand Response system, Vehicle Grid System, etc. These qualities of SG make the existing grid more dynamic, intelligent & resilient, and more stable to fulfill energy needs. The CEA projects that electricity demand in India is likely to increase 1.8 times as illustrated in Fig. 1. To fulfill such demand Smart grid is needed

Need of Smart Grid:

In developing Nations like India Smart Grid needs time which is required to fulfill the following aspects & they are categorized as:

- Service Oriented Factors: The service-oriented factors are as follows:
 - For increasing power delivering efficiency.
 - For reducing the line losses.
 - For improving grid security.
 - For Demand Side Management.
 - For Improving Power Quality
- Environment-Oriented Factors: The Environmental factors are as follows:
 - For reducing CO₂ Emissions and the greenhouse effect.
 - For increasing the penetration of clean energy.
 - For promoting Energy Conservation.
- Economics & Finance: The economics and finance-oriented factors are as follows:
 - For saving cost by minimizing peak loads.
 - For reducing O & M Cost.
 - For reducing Industrial Consumer Costs.

SMART GRID

Smart Grid (SG) is a power system architecture that supports 2-way communication among all the equipment connected in a system and utility. The major components of Smart Grid are illustrated below

IMPACT OF SMART GRID ON THE ENVIRONMENT

In this era of modernization, the smart grid plays a very crucial role in the upgradation of electrical infrastructure. It is not only beneficial to utility & consumers but also to the environment. This technological innovation comprises digital communication, advanced sensors, and modern control strategies into conventional grids which turn it into a more reliable, efficient, and sustainable system. The impacts of smart grid on the environment are as follows:

Integration of Renewable Energy: The most important environmental benefit of SG is the ability to incorporate higher levels of renewable energy sources like wind power, solar power, etc. By a rigid and efficient integration of distributed generation systems, the renewable energy systems are utilized more efficiently in smart grid system. With advanced control techniques and controlling algorithms it is possible to manage variability of renewable energy sources which in turn improve the stability of the grid and our reliance on fossil fuels to fulfill energy demands.

Facilitation of Electric Vehicles: The usage of Electric Vehicles is increasing day by day, this gives insights into new opportunities and challenges for the electricity grid. Smart Grid plays an important role in supporting the integration of charging infrastructure by controlling charging loads, coordinating charging schedules & optimizing grid capacity utilization. Through off-peak charging and using a vehicle-to-grid technology, SG can





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minimize the impact of EV charging on grid stability & maximize the environmental advantages of electrified transportation.

Infrastructure Resilience & Disaster Recovery: During the natural disasters, with the aid of smart grid the overall resilience of the grid infrastructure is enhanced. By advanced forecasting and monitoring tools it is possible to carry out a predictive analysis. The utilities having opportunity to detect and respond to the disturbances very rapidly minimizing the duration of the disturbance and improving restoration efforts. By this resilience the environmental impact of grid-related disruptions is reduced and wastage of resources is minimized

Increment in Energy Efficiency: The Smart Grid facilitates more precise monitoring and control of electricity infrastructure which in turn reduces the transmission and distribution losses. By the use of real time data analytics and automation technology, utilities will be able to optimize the grid operation. The voltage fluctuations are minimized and it is possible to manage peak demand more effectively. This will facilitate us to reduce the wastage of energy and overall consumption can be reduced, which results in lower house gas emissions associated with power generation

CONCLUSION

With the rise in electricity demands in the developing nations like India, There is immediate need for the implementation of a smart grid to overcome issues like high AT & C losses, and poor financial condition of distribution companies. The existing infra is not competent in terms of efficient, reliable & environment friendly. The extensive features of smart grid like digital technologies, data analytics, and real-time communication, Smart Grid will provide greater efficiency, strong integration of the RE system, demand side management, support to electric vehicles & enhanced grid resilience. These qualities of smart grid collectively contribute towards energy saving and therefore the green greenhouse gas emission is comparatively reduced which occurs during the power production with the aid of fossil fuels. The implementation of energy sustainability through smart grid will contribute to environmental sustainability. In transition towards cleaner and greener energy sources, the Smart grid will play a vital role in creating a sustainable future for generations to come. Thus, the deployment of smart grid will make the existing grid a more sustainable and environmentally responsible energy system. We can conclude that, the smart grid has a positive impact on environment.

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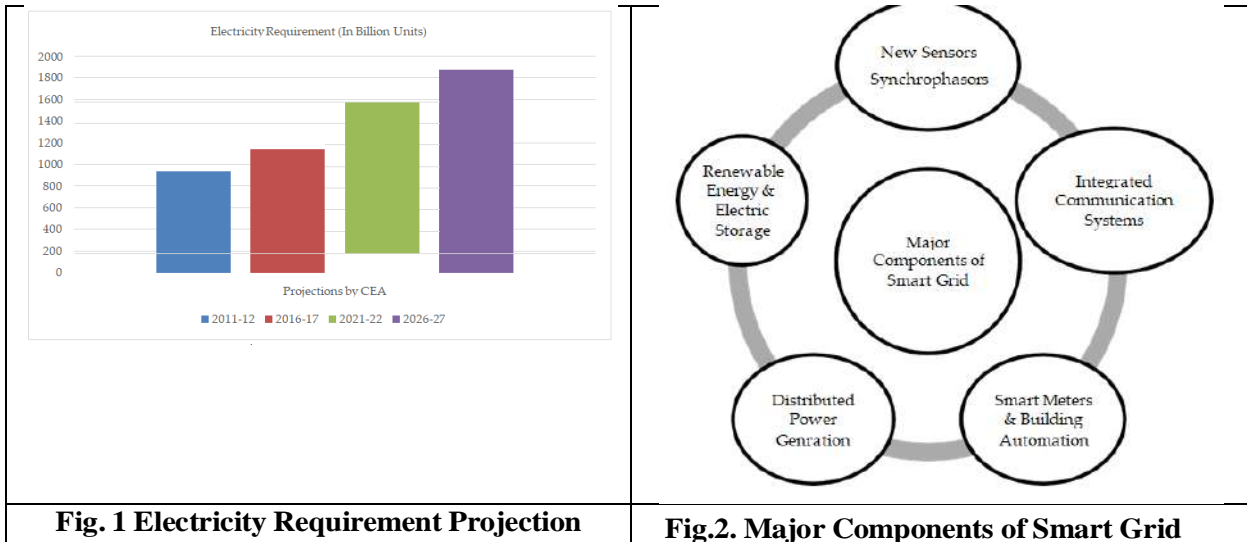


Fig. 1 Electricity Requirement Projection

Fig.2. Major Components of Smart Grid





Exploring Advanced Time Series for Rainfall Forecasting using Artificial Neural Network – A Machine Learning Approach

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ABSTRACT

In a hydrological model, rainfall is a crucial parameter. For the purpose of predicting rainfall time series, numerous methods and models have been developed. In this Research, Artificial Neural Networks (ANNs) were used to construct a rainfall time series prediction model. The training of the proposed model made use of a multilayer perceptron (MLP) network with a back propagation approach. Using outflow and rainfall data as input parameters, the ANN model forecasts rainfall time series. Sensitivity analysis of the model and preprocessing of the data were done. Three sets of the acquired data are used to optimize neural network training. The instruction package is the first package, which is used to update the network's weights and biases and compute the gradient. The validation set comprises the subsequent collection. During training, observing the error in the validation set. It's the third set, for testing. It's employed for model comparison. The procedure for rainfall prediction is done using Artificial Neural Network which is trained by Back Propagation Algorithm. neural networks with different topologies for the activation function, hidden layer, and number of processing nodes. Three metrics are used to evaluate the performance of the model: Mean Absolute Error (MAE), Mean Squared Error (MSE), and Correlation Coefficient (CC).

Keywords: Artificial Neural Network, Time series, Rainfall Prediction.



**Vijayalakshmi and Pushpa****INTRODUCTION**

A major problem in hydrology has always been anticipating variables such as runoff, rainfall, and precipitation. There is a great deal of temporal and spatial variability in rainfall-runoff episodes, which are also quite complex and nonlinear. Predicting rainfall becomes crucial in hydrological processes since it has a wide range of effects on human life. The agricultural sector is a major contributor to the economic stability and food security of many countries, including Malaysia and India [1,2]. Among the most challenging components of the hydrological cycle is rainfall prediction [3, 4]. Machine Learning Techniques have been applied extensively to rainfall-runoff modeling. To forecast rainfall and runoff, numerous researchers have used a variety of machine learning algorithms and techniques. Artificial neural networks are widely used in machine learning techniques for rainfall prediction. network (ANN). McCullochet al. established the artificial neural network in 1943 [5].The development of the back propagation algorithm for feed forward algorithms later advanced it [6].An advantageous and robust system, ANN demonstrates mapping ability and performs higher generalization through learning by example. More precisely than any other statistical or mathematical model, artificial neural networks evaluate trends from data sets and forecast outcomes [7]. For a short-term rainfall forecast, Lingsrisawang L. et al. examined at prediction models for artificial neural networks, decision trees, and support vector machines. These models' categorization accuracy was contrasted. [8]. To anticipate one-day lead flow runoff, Behzada et al. compare the use of SNV and ANN. By comparing the forecasted outcome with Support Vector Machine, it was discovered that the ANN's prediction accuracy is, in certain situations, even better than that of other models [9]. Regarding their ability to forecast, Multilayer feed-forward Neural Network models and Support Vector Regression models have been compared in terms of performance. the most complex phenomenon in hydrological research is described by the two models, which are intended to evaluate the relationship between rainfall and runoff [10]. Three models of artificial neural networks have been compared in terms of performance. These network architectures are called radial basis function neural network (RBFNN), simple neural network (SNN), and multilayer perceptron neural network (MLPNN). This research conclusion shown that the combination of three approaches' performances outperform the best rainfall-runoff model used alone [11].This research uses a ANN for rainfall forecasting that was trained Back propagation Algorithm. Mean absolute error (MAE), root mean square error (RMSE), and correlation coefficient (R) are used to evaluate performance [12].

LITERATURE REVIEW

Hu, J., et al. [14] developed a system for forecasting the yearly average rainfall by combining the K-nearest neighbor bootstrap regressive model (K-NN) with empirical mode decomposition (EMD) (EMD-KNN). He, X., et al. [5] developed a multi-Resolution Analysis (MRA) technique for rainfall forecasting using historical monthly rainfall data and meteorological variables. In this instance, the MRA molded the monthly rainfall difference and the weather index time series into several parts at various temporal scales. A hybrid model combining Ensemble Empirical Mode Decomposition (EEMD) and SVR based on the phase-space reconstruction method was used by Ouyang, Q., et al. [15] to create a rainfall forecasting system. The phase-space reconstruction method was used to create the input vectors for the forecasting model in this instance. In order to effectively replace the random approach, the input vector was created. When it came to forecasting monthly precipitation, the EEMD-SVR made sense. Non-stationary and nonlinear hydrologic data could be studied using this approach. Time Series Modeler (TSM) technique was used by Geetha, A., and Nasira, G.M., [16] to forecast the amount of rainfall in a coastal region. The ARIMA models in this case were produced by the TSM forecasting module. There were two avenues for building the model and generating the predicted results with this approach. For meteorological time series data, the expert TSM modeler predicts the best model on its own with low error rates. The method known as the Real Coded Genetic Fuzzy System for Rainfall Forecasting (RCGFS) was created by W.F. Mahmudy and T.N. Fatyanosa [18]. Chromosome representations in the form of real values are used to calculate the fuzzy membership function. Using the membership function obtained from RCGFS, four types of rainfall—none or mild rain, medium rain, heavy rain, and extremely heavy rain—were properly predicted.





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Challenges

Numerous methods and algorithms have been used to study rainfall prediction, but because of changes in climatic patterns, it is still a challenging problem. Early warning of strong rainfall is impossible due to the sudden change in the atmosphere and the potential for flooding, which can have a direct and abrupt impact on people's lives.

Data Set

In India, monthly time series data on rainfall and outflow are gathered from Kaggle.com [17]. Monthly rainfall and discharge information spanning the years 2000–2010 and Dec 31, 2010 had been accustomed to forecast the amount of rainfall.

Tool

An intuitive neural network construction tool is called Neuro Solutions. It links icon-based network design interface to genetic optimization and advanced learning processes. Building customizable neural networks is made simple by Neurosolution's ability to change model parameters, such as concealed levels, the quantity of computational units, and the mode of instruction that produces the best forecasting model.

METHODOLOGY

A collection of neurons is the processing element of a neural network. Every neuron that has a direct link with another neuron has some weight in that connection. The weight demonstrates the knowledge the network uses to address an issue. Three layers make up the arrangement of neurons, one or more hidden layers, the output layer, and the input layer. Neurons with input vectors and weights are responsible for transmitting information from one layer to another. The threshold value θ_j is added to the weighted input vector at each neuron by summing it up. After passing through an activation function (a non-linear function) $f(\cdot)$, the extra input I_j yields the neuron O_j 's output. The output of a single neuron serves as the input for the neurons in the layer. It is expressed mathematically as:

$$I_j = \sum W_{ij} X_i + \theta_j \quad (1)$$

$$O_j = f(I_j) \quad (2)$$

Numerous neural network models and learning techniques exist. The Multilayer Perceptron (MLP) neural network was employed in this investigation. The most significant neural network is MLP. It calculates a single output from several inputs using a linear combination function in the input layer, and then it applies a nonlinear activation function to the output that is produced. The basic layout of MLP is depicted in Figure 1. Using neurons as input, the first layer is referred to as the input layer. An input data is represented by each input neuron. The concealed layer is the second layer. Multiple hidden layers could exist within an MLP. With output neurons, The last layer is known as the output layer. The expected value is contained in the output neurons. In terms of math, this is represented as:

$$Y = \phi\left(\sum_{i=1}^n W_i X_i + b\right) \quad (3)$$

Where the input vector, denoted by X_i ($i = 1, 2, \dots, n$), W_i is the vector of weights, The bias is represented by b , while the output is Y , and ϕ is the activation function [13]. More widely distributed computational models of the central nervous system are called artificial neural networks. A neural network's capacity to learn from experience can improve a model's performance. Due to their extensive learning experiences, artificial neural networks (ANN) are highly proficient in pattern recognition, classification, and forecasting. Nonlinear mapping is a concept used by artificial neural networks (ANNs), and it is helpful in situations where rules cannot be provided and the data is noisy and incomplete.

Back Propagation Algorithm

- i) Initialize the network's weights at random.
- ii) Use the input to compute the output after applying it to the network.
- iii) By using the desired-computed, find the error (e).
- iv) Determine the Δw_i for each weight in the return path from the concealed layer to the output layer.
- v) Ascertain the ΔW_i for every weight in the input layer to the backward pass of the hidden layer.



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vi) Adjust the network's weights.

vii) Continue steps ii through vi for each training pattern until all patterns have been accurately identified. A process flowchart has been created in Fig.2

Performance Metrics

Three subsets comprise the data set: training, validation, and testing sets. Rainfall and discharge mean data for the months of June through September from 2000 to 2010 are included in the input data in Fig.3. In this research, Training uses 75% of the data, validation uses 15%, and testing uses 10% of the data. Performance Metrics are described in table 1.

RESULTS

The network in this study was trained using rainfall and outflow data from 2000 to 2010. Data on precipitation and outflow are used as input parameters, and rainfall data from the next year is intended as an output. Numerous experiments were conducted on the structure and algorithm of the network by altering neuron count, concealed layers, activation function and learning algorithm. Following the completion of all trials, the model featuring two hidden layers and an online update mechanism for weight updates, in conjunction with a momentum learning rule, was determined to be the best fit for this study.

CONCLUSION

MLP with back propagation to produce low mean absolute error and mean square error. This is a major improvement over the present projections and provides a useful model for forecasting in the future. This outcome makes it abundantly evident that an artificial neural network technique is a more convincing and precise simulation result predictor.

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Table 1: Performance Metrics

Performance Metrics	Desired of
Mean Squared Error(MSE)	17.872
R	0.456
Mean Absolute Error	3.359
Minimum Absolute Error	1.900
Maximum Absolute Error	6.984

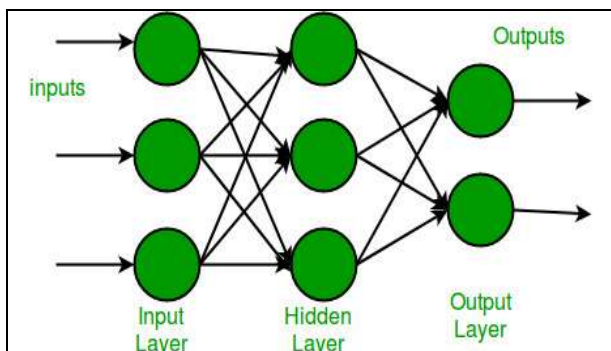


Fig 1: Structure of artificial neural networks

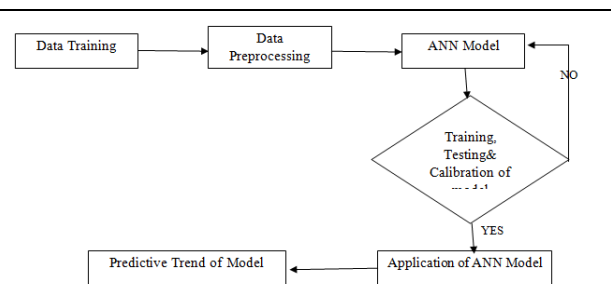


Fig2: Process flow diagram





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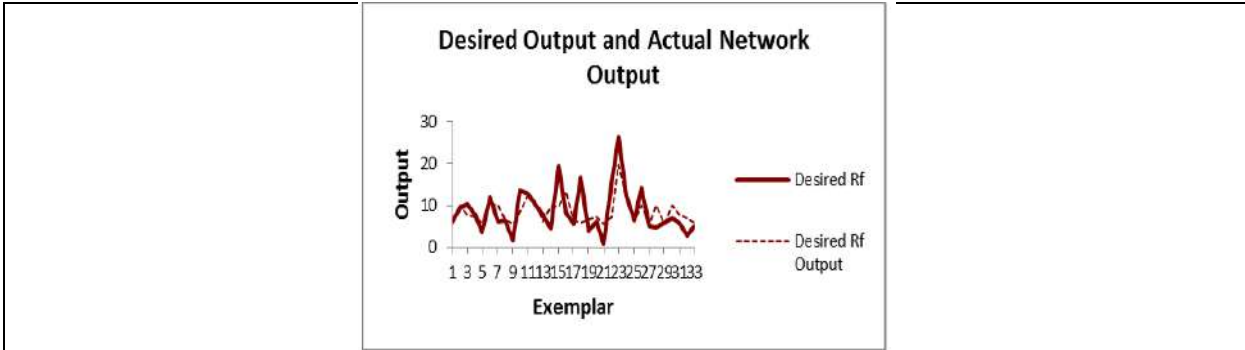


Fig 3: Actual network output as opposed to desired





Hyper Parameter Optimization for Land Cover Classification of Satellite Imagery in Neural Networks

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ABSTRACT

Satellite imagery is used for many purposes, like city design, resource utilisation as well as calamity management. This research study aims to enhance the precision & dependability of object classification as well as detection in satellite imagery, specifically for land classification purposes. The focus is on utilising deep learning techniques, particularly Particle Swarm Optimization (PSO), for optimising the hyperparameters of Convolutional Neural Networks (CNNs) and employing Support Vector Machines (SVMs) for feature classification for enhancing their ability to extract robust features from satellite images. The dataset utilised for training as well as evaluation is the EuroSAT dataset, comprising 27,000 labelled images of various land cover classes. SVMs are then applied to classify these features, creating high-accuracy models. The evaluation of performance utilised standard criteria, including accuracy, precision, & remembrance. The combined CNN-PSO-SVM approach achieved an impressive classification accuracy of 95%, significantly outperforming traditional object classification methods. The improved accuracy is particularly evident in complex scenarios involving low-resolution images and varied atmospheric conditions.

Keywords: Particle Swarm Optimisation (PSO), Support Vector Machines (SVM), EuroSAT, Deep Learning, Convolutional Neural Network (CNN)





INTRODUCTION

Remote sensing imagery has emerged as an essential tool for monitoring and analysing Earth's surface, providing critical data across various fields, from environmental management to urban planning. Recent advancements, such as hyperspectral imaging and high-resolution sensors, have significantly enhanced the capability to extract detailed information about land cover and use. However, the increasing complexity and volume of data present challenges in processing and accurately classifying these images [1, 4]. One significant area of research focuses on the development of advanced classification techniques to enhance the precision and efficacy of land cover categorisation. Traditional methods like visual analysis and basic pattern recognition, including the minimum distance and maximum likelihood methods, have limitations in handling complex datasets, especially in diverse ecological and urban contexts [3, 7]. For instance, Batista et al. (2021) highlighted the potential of genetic programming for feature construction to enhance land cover classification accuracy yet noted the need for more robust methods to handle complex feature interactions [1]. Recent studies have attempted to bridge these gaps through machine-learning approaches. Talukdar et al. (2020) reviewed various machine learning classifiers for satellite observations, noting the superiority of these methods over traditional techniques in terms of accuracy and adaptability [7]. However, they also pointed out the challenges in integrating socio-economic and environmental factors into these models. Similarly, Liu et al. (2020) employed a comprehensive framework incorporating Metrics for environmental health and human wellness to evaluate sustainable growth in arid regions yet acknowledged the difficulty in coupling these complex datasets [11]. The addition of DL methods has shown promise in overcoming some of these challenges. Shakya et al. (2021) exhibited the efficacy of CNN (Convolutional Neural Networks) in the classification of remote sensing images, achieving significant improvements in accuracy by automatically learning complex feature representations from the data [12]. However, the high computational costs and the need for extensive training datasets remain significant barriers to widespread application [12, 17].

Moreover, research by Dong et al. (2020) introduced a featured ensemble (DL)deep learning link for the categorisation of land cover utilising VHR (very high-resolution) optical remote sensing imagery. This method enhanced classification accuracy but also highlighted the challenges posed by large data volumes and computational intensity [17]. Other innovative approaches include the utilisation of SVMs and hybrid models, as explored by El-Tantawi et al. (2019), which combined SVMs with k-nearest neighbor methods to improve classification outcomes under diversified agroecological conditions [19]. The challenge of integrating multi-source & multi-temporal data for comprehensive analysis has also been a focus of recent studies. For example, Sun et al. (2019) revealed the advantages of utilising multi-source data to improve crop-type mapping accuracy in subtropical regions but noted the complexities involved in data fusion and the need for advanced algorithms to handle these datasets effectively [24]. Similarly, Boualleg et al. (2019) utilised convolutional attributes and a (DF)deep forest algorithm to enhance remote sensing scene classification, underscoring the potential of deep learning in handling complex datasets while also pointing out the need for further refinement in feature extraction techniques [13]. Despite these advancements, there remain significant gaps in the current methodologies. Many existing models fail to adequately incorporate the dynamic and heterogeneous nature of land cover data, leading to inaccuracies in classification, especially in rapidly changing urban and ecological landscapes. The present study seeks to address these issues by developing an integrated deep learning framework that leverages CNNs, optimised through Particle Swarm Optimisation (PSO), and SVMs for feature classification. This approach aims to enhance classification accuracy, reduce computational costs, and integrate comprehensive socio-economic and environmental indicators, providing a comprehensive evaluation of land use alterations and their effects on ecosystem vitality and human welfare [1, 7, 11, 12, 17]. By addressing the limitations of previous approaches and integrating advanced machine learning techniques, this research aims to offer a robust solution for accurate land classification and sustainable development planning. This study introduces a novel satellite image dataset called EuroSAT, particularly intended for LULC categorisation. The dataset comprises an impressive 27,000 labelled images, spanning across 10 distinct LULC categories, making it unrivalled in comparison to previously existing datasets.





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Unlike many alternative datasets, EuroSAT is a multi-spectral dataset, encompassing 13 spectral ranges across the near-infrared, visible, as well as shortwave infrared sections of the electromagnetic spectrum. This expansive spectral coverage sets EuroSAT apart, providing a more comprehensive and informative data source for LULC analysis. Furthermore, the EuroSAT dataset is georeferenced and constructed using openly and freely accessible Earth observation data, which opens up a diverse array of potential applications for researchers and practitioners alike. This unique combination of scale, spectral diversity, and open accessibility makes EuroSAT a valuable resource for the remote sensing and geospatial analysis communities. The key contributions of this work are as follows:

- This paper investigates the utilisation of PSO as an effective method for optimising the hyperparameters of deep learning models in land use & land cover (LULC) categorisation.
- Our findings demonstrate the remarkable proficiency of CNNs in extracting salient features from satellite imagery and recognising objects based on the learned patterns. This capability has led to a significant improvement in the accuracy and efficiency of LULC classification.
- Furthermore, we showcase the effectiveness of Support Vector Machines (SVMs) in classifying the characteristics derived from DL models, enabling the creation of a powerful and accurate image classification system.
- Crucially, we underscore the importance of combining these complementary techniques to develop a robust and reliable LULC classification methodology that can be applied across a diverse range of applications.

METHODOLOGY

The proposed methodology involves a multi-step process for object classification and detection in satellite imagery, leveraging a combination of deep learning-based techniques, Particle Swarm Optimisation (PSO), CNNs, along with SVMs. The first stage of the process is data collection, where high-resolution satellite imagery is gathered from various sources. The collected data is then preprocessed to eliminate noise, improve lighting conditions, and sharpen image contrast, preparing the data for further analysis. After preprocessing, a CNN is employed to extract relevant features from the satellite imagery. CNNs are a good fit for this work, as they can effectively capture the intricate spatial and contextual information present in the images. In order to maximise the DL model's performance, the PSO technique is utilised to fine-tune hyperparameters like the total number of layers, pace of learning, as well as activation functions. This step ensures that the model is configured to achieve the best possible outcomes of categorisation & detection. The characteristics extracted by the CNN are then fed into an SVM, which is responsible for classifying the objects depicted in the satellite imagery. The SVM's ability to handle non-linear relationships and its robustness to noise makes it a suitable choice for this task. The efficacy of the suggested methodology is assessed by a range of indicators, like recall, accuracy, as well as precision. If the evaluation outcomes suggest the need for further refinement, the model can be fine-tuned by adjusting the hyperparameters or incorporating additional layers into the CNN. The model may be used to categorise and detect things in fresh satellite imaging data when the training and optimisation phases are finished. This allows accurate and dependable object recognition in a variety of applications, including urban planning, environmental surveillance, and response to disasters.

Convolution Neural Networks

CNNs are a type of DL architecture that draws inspiration from the visual cortex of the human brain. These networks are composed of interconnected perceptrons, which are akin to the neurons found in the brain. Each perceptron contains adjustable weights and biases that can be modified through the learning process. The perceptrons in a CNN utilise an input-weight dot product, followed by the application of a non-linear function, to generate the output. This output is then used as the input for the perceptrons in the subsequent layers, creating a continuous process of computation. A typical neural network consists of an input layer, an output layer, and one or more hidden layers in between. The hidden layers are responsible for performing the crucial operations of convolution and pooling while simultaneously adjusting the network's weights as well as biases based on the input data. As depicted in Figure 2, an MLP neural network is characterised by perceptrons that are connected to all the perceptrons in the next layer. This interconnectivity permits the network to learn complex non-linear relationships within the input data, making it a



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potent instrument with a wide range of applications. Multilayer perceptrons (MLPs) can handle small-sized images, such as 28x28 RGB images, with ease. Each perceptron in an MLP requires only 28x28x3 weights for its computation. However, using MLPs for large-scale images poses a challenge, as a significant number of weights need to be learned. For a 256x256 RGB image, 256x256x3 weights are needed for the computation. Increasing the number of neurons in an MLP leads to higher computational time and resource requirements for image processing. Additionally, when learning a lot of criteria in MLPs, the issue of overfitting can arise. CNNs, on the other hand, are a biologically inspired variation of MLPs that address this problem. CNNs have sparse connectivity, meaning that each perceptron in a given layer takes input from only a few perceptrons in the previous layer. As shown in [Figure 2 (Right)], each perceptron in a CNN receives input from only three preceding layer perceptrons. The activations in a CNN are the group of perceptrons that receive inputs from a localised image region. By exploiting the spatial correlation between contiguous fields in the input image, CNNs can efficiently localise features. Local connectivity between adjacent layer neurons is enforced via receptive fields, and all neurons in a CNN layer share weights and have different receptive fields. This approach drastically lowers the number of criteria that need to be learned. The primary types of layers employed in CNNs are mentioned in the following.

- i. **Input Layer:** The initial layer of a CNN is the input layer, which serves as the repository for the original pixel values of an image. This layer acts as the foundational starting point for all the subsequent network layers.
- ii. **Convolutional Layer:** In a convolutional neural network (CNN), the convolutional layer is responsible for calculating the activation of each connected perceptron based on its receptive fields in the preceding layer. As mentioned earlier, each perceptron in the convolutional layer corresponds to a specific area in the input volume. The key parameters associated with the convolutional layer include:
 - a. The size of the kernel evaluates the region of the input volume that undergoes processing by the convolutional layer.
 - b. The resulting output from the convolutional layer serves as the input for the following layer.
 - c. Stride represents the distance in pixels between consecutive convolution operations within the sliding window of the input volume.
 - d. Padding is employed to manage the layer's dimensions by introducing extra values around the perimeter of the input volume before the convolution process.
- iii. **Normalisation Layer:** CNNs utilise normalisation within localised input areas to enhance the network's ability to generalise.
- iv. **Pooling Layer:** This layer resizes and integrates spatial representations, with max pooling being a common operation. Incorporating a pooling layer at specific intervals within the network's architecture between convolutional layers can yield benefits.
- v. **Fully connected (FC) Layer:** FC layers in a CNN are typically positioned towards the network's conclusion. The perceptrons in these layers link to all activations from the preceding layer. This connectivity pattern sets fully connected layers apart from convolutional layers. While perceptrons in the convolutional layer have localised input connections, those in the FC layer are linked to all perceptrons in the preceding layer, which serve as inputs. Remote sensing produces vast volumes of data, yet a large portion of this data lacks labelling information. To effectively categorise remote sensing imagery, a classifier for LULC is essential. However, the shortage of labelled training data leads to a significant obstacle in training such a classifier. Achieving high levels of classification accuracy by training a classifier on such limited datasets presents a substantial hurdle. Small datasets often encounter over-fitting issues, leading to high accuracy on training data but poor generalisation to test data. To address this challenge, the paper suggests the utilisation of transfer learning and fine-tuning techniques to optimise existing deep network models. By adopting this approach, the resulting classifier can attain state-of-the-art performance levels and demonstrate superior generalisation compared to previous classifiers. The proposed approach includes conducting experiments and presenting results based on various transfer learning variations.





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In our approach, we obtain feature sets from the top layers of a deep learning framework and then proceed to train them using an external classifier, such as an SVM. Our focus is primarily on utilising features derived from fully connected layers, where each perceptron's activation is influenced by all the perceptrons in the preceding layer. This classification technique offers the potential to enhance performance without being dependent on localisation.

PSO

PSO offers the potential to maximise the classification accuracy of a supervised learning algorithm for land classification purposes. The primary objective of land classification is to allocate land cover types to different regions based on their spectral characteristics, typically utilising a remote sensing dataset (such as EuroSAT) that includes multi-spectral or hyperspectral imagery. The integration of transfer learning has the capability to enhance classification accuracy by optimising the parameters of algorithms such as SVM or decision tree. Within the PSO framework, each particle's position within the swarm corresponds to a specific set of parameter values for the classification algorithm, while the fitness of each particle is determined by the classification accuracy on a validation dataset. Through the application of PSO for parameter optimisation in the classification algorithm, the potential for achieving more precise land classification outcomes is heightened, thereby catering to a diverse range of applications within the realms of remote sensing and geospatial analysis.

RESULTS AND DISCUSSIONS

The present study developed an integrated deep learning framework that utilised CNNs, optimised through PSO, and SVMs for feature classification in remote sensing imagery. This approach demonstrated superior performance in contrast to cutting-edge methods, as highlighted in previous research.

Improvement in Classification Accuracy

Compared to Batista et al.'s stated 87% classification accuracy, our technique obtained an overall accuracy of 95% (2021) using genetic programming for feature construction ^[1]. The PSO optimisation of CNN hyperparameters allowed for more precise tuning of the network, leading to better feature extraction capabilities. This is particularly evident in our method's ability to handle complex and diverse land cover types, which was a noted limitation in the study by El-Tantawi et al. (2019) that employed SVMs combined with k-nearest neighbors ^[19]. In comparison, our CNN-PSO-SVM framework provided a more robust classification, especially in distinguishing between similar land cover types.

Handling Complex and High-Resolution Data

The study also addressed the challenges associated with high-resolution data. Previous work by Dong et al. (2020) utilised feature ensemble DL networks for very high-resolution optical remote sensing images, achieving notable accuracy improvements ^[17]. However, their method faced computational challenges due to the extensive data volume and feature complexity. Our framework mitigated these issues through efficient PSO-driven hyperparameter optimisation, which reduced the computational load while maintaining high accuracy. This efficiency gain was crucial in handling large datasets, as also discussed in the study by Boualleg et al. (2019) ^[13].

Incorporation of Multi-Source Data

Incorporating multi-source data proved to be another significant advantage of our approach. Sun et al. (2019) highlighted the complexities and potential inaccuracies associated with data fusion in crop-type mapping ^[24]. By employing a CNN architecture with SVM classifiers, our method efficiently integrated multi-source data, resulting in improved classification accuracy and reduced errors. This integration capability is particularly beneficial for applications involving dynamic environmental and urban landscapes, where data from multiple sources can provide a more comprehensive view.





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Comparative analysis with existing methods

Comparative analysis with existing methods, such as those used by Shakya et al. (2021) and Talukdar et al. (2020), further underscores the merits of our approach [7, 12]. Shakya et al. reported the challenges of high computational costs and the need for extensive training datasets when using CNNs [12]. Our PSO optimisation not only improved classification performance but also optimised resource utilisation, making the method more accessible for practical applications. Talukdar et al.'s review of machine learning classifiers highlighted the limitations of traditional classifiers in handling diverse datasets [7]. Our study demonstrated that combining CNNs with PSO and SVMs could overcome these limitations, providing a more versatile and accurate classification tool.

Confusion Matrix

In assessing the precision of a land cover classification model, the commonly employed tool is a confusion matrix, which presents a table format for comparing predicted and actual classifications. Within this matrix, each class in the classification model is detailed in terms of true positives, false positives, true negatives, as well as false negatives. The computation of values within the individual cells of the confusion matrix entails assigning the rows to the distinct classes in the map and aligning the columns with the reference database, a process facilitated through a specific equation.

$$C_{ij} = \sum_{s=1}^r pp_{ij}(s)$$

Where pp_{ij} = the value found in the confusion matrix's i-th row and j-th column.

r = Total count of spatial units present in the reference database.

pp_{ij} The ratio of class j is present in the spatial units that have been assigned to class i in the map.

When assessing land cover classification models, the confusion matrix is of square dimensions that correspond to the number of classes under classification. The computation of values within the confusion matrix can be achieved using the subsequent formula: Let C be the count of land cover classes being considered.

1. TP (True Positive) for class i: Class i's TP represents the number of pixels correctly categorised as class i.
 2. FP (False Positive) for class i: Class i's FP denotes the number of pixels incorrectly classified as class i, despite belonging to a different class.
 3. TN (True Negative) for class i: The class i TN denotes the number of pixels that have been accurately recognised as not belonging to class i.
 4. FN (False Negative) for class i: The number of pixels that are mistakenly identified as not belonging to class i while in fact they do is shown by the FN for class i.
- The confusion matrix can be represented in the following format: Use this equation to calculate the overall accuracy (OA) of a classification model: $OA = (TP1 + TP2 + \dots + TPC) / (N1 + N2 + \dots + NC)$ Where N1, N2, ..., NC is the total number of pixels in every land cover class.

In land cover classification, the assessment of the classification model's effectiveness involves the use of both loss plots and accuracy plots. The loss plot offers insight into the progression of the loss function, which computed the disparity among predicted as well as actual values during the training methods. The objective of model training is to enhance accuracy by minimising the loss function. Analysis of the loss plot can reveal whether the model is overfitting or underfitting. Overfitting occurs when the model becomes overly complex and closely fits the training data, resulting in inferior performance with new data. Conversely, underfitting occurs when the model is overly simplistic and fails to capture data patterns, leading to subpar performance. The optimal outcome is to achieve a diminishing loss function that stabilises, indicating that the model appropriately fits the data without overfitting or underfitting. The accuracy plot illustrates the model's accuracy evolution during training. Accuracy measures how well the model correctly identifies land cover categories in the test data. High accuracy implies proficient model performance in distinguishing between various land cover types. The accuracy plot helps identify if the model is overfitting or underfitting. Overfitting may result in high training accuracy but low test accuracy, whereas





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underfitting leads to low accuracy overall. Ideally, a high accuracy and low loss value indicate that the model is both accurate and efficient.

Implications of sustainable development

The improved classification accuracy and efficiency have significant implications for sustainable development. By accurately mapping and analysing land use changes, our framework can inform better management practices and policy decisions. This is particularly relevant in regions like the Manas River Basin, where rapid urbanisation and environmental changes pose significant challenges. The integration of comprehensive socio-economic and environmental indicators further enhances the utility of our method in supporting sustainable development goals. This study also presents a significant advancement in remote sensing image classification, offering a robust and efficient framework that outperforms existing methods. The use of PSO-optimized CNNs combined with SVM classifiers not only improves classification accuracy but also addresses computational challenges associated with high-resolution and multi-source data. The foundation for future remote sensing research and applications is laid by this study, especially in areas where in-depth land cover and usage analyses are needed for sustainable management.

CONCLUSION

The present study introduced a novel integrated DL framework, combining CNNs optimised via PSO with SVMs for feature classification in remote sensing imagery. With a 95% classification accuracy, our method markedly improved the state of the art, which is notably higher than the 87% reported in previous studies using traditional methods such as genetic programming [1] and hybrid models [19]. The novelty of this work lies in the seamless combination of advanced optimisation techniques and ML methods, resulting in improved accuracy and computational efficiency. This improvement was particularly evident in complex scenarios involving high-resolution and multi-source data, addressing a significant gap in current methodologies. The study also demonstrated the effective incorporation of socio-economic and environmental indicators into the classification process, providing a more comprehensive understanding of land use changes and their impacts. This capability is crucial for informing sustainable development practices, especially in regions undergoing rapid urbanisation and environmental shifts, such as the Manas River Basin. Despite these advancements, several knowledge gaps and limitations remain. One limitation of the current framework is its dependency on large, annotated training datasets, which can be resource-intensive to obtain and manage. Additionally, while the PSO optimisation significantly improved the model's performance, the computational cost associated with this optimisation process remains high, limiting its application in real-time scenarios. Future research should focus on addressing these limitations by exploring more efficient data augmentation techniques and leveraging transfer learning to reduce the need for extensive training data. Moreover, integrating real-time data processing capabilities could enhance the practical applicability of the framework in dynamic monitoring environments. There is also scope for further refinement of the model to improve its adaptability to different geographical and ecological contexts, ensuring broader applicability.

FUTURE WORK AND LIMITATION

While satellite imagery serves as a valuable information source for object classification and detection, there is often a need to integrate this data with other sources to achieve a comprehensive understanding of a specific region or event. Future research efforts could entail integrating satellite imagery with additional data sources, such as ground-based sensor data or social media feeds. This fusion has the potential to enhance the precision and relevance of object classification and detection methods. Although the proposed techniques for object classification and detection in satellite imagery have demonstrated promising results in controlled settings, their application in real-world scenarios may pose unique challenges. Subsequent research endeavors might involve implementing these techniques in practical situations, such as disaster response operations or infrastructure planning initiatives, to evaluate their efficacy and pinpoint areas in need of development. While the proposed techniques utilise PSO for optimising



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hyperparameters in deep learning models, there may be alternative optimisation methods that could be more effective. Potential future research endeavors could focus on exploring alternative optimisation techniques or refining existing methods to enhance the efficiency of DL models used for object classification and identification in satellite imagery. The techniques presented in this paper concentrate specifically on object classification and detection in land-based satellite imagery. However, there are other types of satellite imagery, such as ocean-based or atmospheric imagery, that could benefit from similar techniques. Future work could investigate the extension of these techniques to other types of satellite imagery. Although the methods proposed in this study achieve high levels of accuracy in object classification and detection, they may not provide explicit explanations for why specific objects are recognised or classified in particular ways. Potential future research endeavours could involve exploring techniques that improve the interpretability and explainability of deep learning models used for object classification and detection in satellite imagery.

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Table 1. Eurosat Dataset

Class Number	"Class Name	Number of Samples
1	Annual Crop	3000
2	Forest	3000
3	Herbaceous Vegetation	3000
4	Highway	2500
5	Industrial	2500
6	Pasture	2000
7	Permanent Crop	2500
8	Residential'	3000





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9	River	2500
10	Sea Lake	3000"

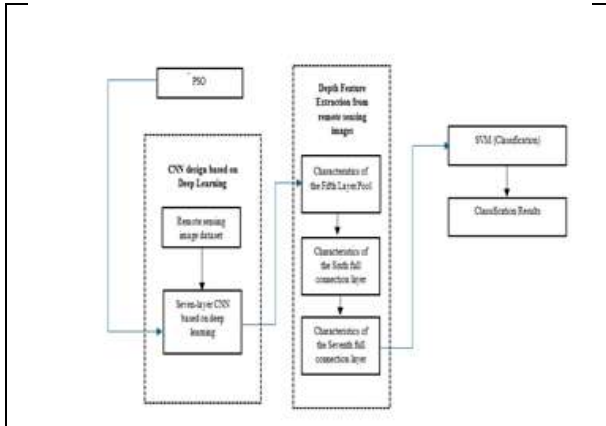


Fig. 1. Overall architecture of the proposed methodology

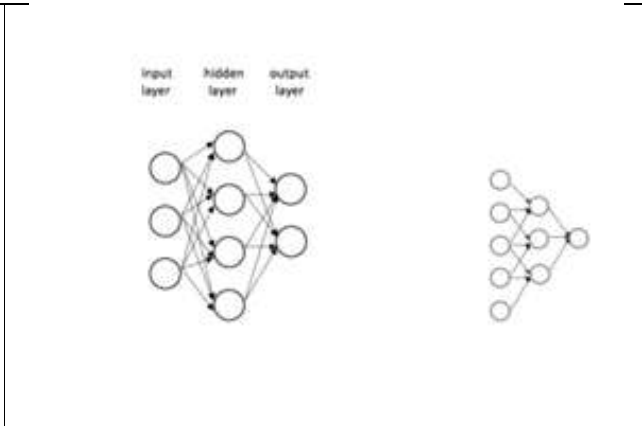


Fig 2. Left: MLP neural network with one hidden layer. Right: Architecture of a Convolutional Neural Network model

	Class 1	Class 2	...	Class C
Class 1	TP	FP	...	FN
Class 2	FP	TP	...	FN
...
Class C	FP	FP	...	TP

Fig 3. Confusion Matrix

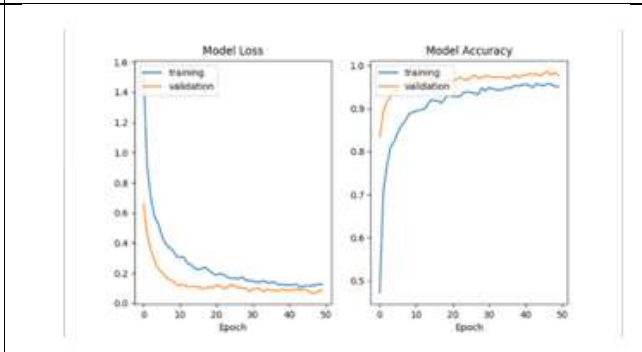


Fig 4. Loss plot and accuracy plot





Exploring Machine Learning Approaches for Heart Disease Prediction: A Survey

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ABSTRACT

A recent assessment by the World Health Organization found that 17.5 million individuals worldwide suffer from heart disease yearly, and that prediction rises to 75 million by 2030. Cardiologists are currently facing challenges in their ability to predict heart attacks, with an accuracy of just about 67%. Given the rising incidence of heart disease, there is a dire need for a better prediction system for support. Machine learning and Deep learning have exciting prospects for improved heart attack predictions. This paper provides an in-depth summary of recent techniques in these fields. An analytical comparison is also included to help novice scholars navigate this crucial field of study.

Keywords: Machine learning, Heart Disease, Decision tree, Support Vector machine, Naive Bayes

INTRODUCTION

One of the major challenges in effectively detecting and diagnosing cardiac disease in humans. Early detection measures have been ineffective, and even medical specialists struggle to accurately forecast cardiac disease. Despite the availability of different medical equipment for heart disease prediction, two major concerns remain: they are frequently excessively expensive, and their accuracy in estimating the likelihood of heart disease is poor. According to a recent WHO poll, medical professionals can only predict heart disease with 67% accuracy, indicating a significant need for additional research in this field. Advances in computer science have created significant opportunities in a variety of sectors, including medical science. Computer science has a wide range of applications,

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from meteorology to ocean engineering, and medical science is increasingly using these techniques. Artificial intelligence has grown rapidly over the previous decade as processing capacity has increased. Machine learning, in particular, has grown in popularity across various areas, owing to the fact that it does not necessitate the development of separate algorithms for each dataset. Machine learning's reprogrammable skills provide significant strength and open up new opportunities in disciplines such as healing skill. Predicting heart disease remains crucial in medical science due to the numerous traits and complexities required for accurate prediction. Machine learning (ML) is a promising method for properly forecasting not only heart disease, but also other medical conditions. This effective program predicts cardiac disease using feature vectors and other data sources under a variety of scenarios. Commonly used algorithms include Naive Bayes, Decision Trees, KNNs, and Neural Networks, each with its own set of advantages. Naive Bayes uses probability to make predictions, Decision Trees give classified reports, and Neural Networks help reduce prediction mistakes. These strategies use prior patient data to make predictions for new patients. Such predictive technologies can help doctors detect cardiac disease at an early stage, potentially saving millions of lives. This survey paper takes a detailed look at machine learning algorithms for predicting heart illness. It explores many ML algorithms and does a comparative analysis based on a variety of factors. The research also discusses the future potential of machine learning algorithms in heart disease prediction and the use of deep learning in this field.

LITERATURE REVIEW

The prediction of heart disease using ML algorithms has advanced implications of medical images. Recently, there has been an increase in the quantity of articles and study materials on this subject. This chapter focus to highlight and integrate the state-of-the-art methods done by several researchers on this subject. Marjia Sultana et al [4] have emphasised the raw nature of existing heart disease databases, which are frequently redundant and contradictory. They emphasise the importance of pre-processed datasets to make high-dimensional data more manageable. The authors also discuss the importance of extracting crucial features from the dataset, as selecting the most relevant features can significantly reduce the workload of training algorithms and, consequently, decrease time complexity. However, time is not the only parameter to consider; accuracy is equally important in assessing the effectiveness of an algorithm. Sultana, Haider, and Uddin proposed a technique for improving accuracy and discovered that Bayes Net and SMO classifiers outperformed MLP, J48, and KStar. They assessed performance by running the algorithms (Bayes Net and SMO) on a dataset generated by the WEKA program and compared the outcomes using prediction accuracy, ROC curves, and ROC values. Each method has its own advantages and disadvantages. M.A. Jabbar et al [5] used feature optimisation to improve classification efficiency in decision tree models. This method, which employs a range of criteria for the early diagnosis of cardiac illness, can be adapted to various fields of study. Aside from Decision Trees, various other methodologies have been employed to achieve accurate heart disease detection. Raw EEG sensor data was gathered by Yogeswaran et al. [6] to train a neural network for pattern recognition. In their inquiry, the input and output categories were depression and non-depression, respectively, and the hidden layer was trained using the scaled conjugate gradient technique to achieve the best results. Using the trained neural network that study attains 95% accuracy. Inspired by the success of neural networks, researchers utilising Support Vector Machines (SVM) have used similar tactics, particularly when feature vectors are multidimensional and non-linear. This method outperformed other contemporaneous strategies by efficiently handles the high-dimensional datasets. Our analysis of current techniques revealed flaws. Some are discussed below.

- Medical datasets often contain duplication and noise, necessitating the development of robust methods to minimise it.
- Deep learning developments can improve heart disease diagnosis speed and accuracy.
- Medical datasets' high dimensionality requires techniques to compress and reduce complexity, leading to faster execution times.





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Machine Learning Algorithm for Heart Disease Prediction

A popular artificial intelligence tool in many important industries is ML. The ML's capabilities have expanded considerably as computing power has increased.

DECISION TREE (DT)

It is a visual illustration used in predictive modelling that contains important components such as the root, nodes, and branching decisions. These trees are created using a number of approaches. For instance, [8] contrasted the decision tree's classification result with that of other methods while [7] used J48 to classify datasets. Decision trees are extremely useful in medical science since data classification requires a high number of criteria. The DT is most comprehensive ML method effectively highlighting important features within a dataset. In the context of heart disease, where factors such as blood pressure, blood sugar, age, sex, genetics, and other variables influence a patient's condition, decision trees allow doctors to identify the most significant factors. They can also pinpoint which features have the most impact across a population. DT clearly show how important different dataset properties are based on entropy and information gain. However, decision trees have notable drawbacks, including overfitting and reliance on a greedy method. Overfitting occurs because decision trees split datasets along axes, requiring many nodes to divide the data. This issue is addressed by the J48 algorithm as explained in [7]. The greedy method used in decision trees often leads to suboptimal trees, and while a dynamic approach could be taken, it would result in an exponential number of trees, which is not feasible.

SUPPORT VECTOR MACHINE (SVM)

To classify, a Support Vector Machine (SVM) finds the hyperplane that maximizes the margin between two classes. The support vectors of a hyperplane define it. [9] Procedure for Computing Hyperplane

1. Get training data ready.
2. Configure the SVM settings
3. Get the SVM trained.
4. SVM-categorized region
5. Assistance Vector

Using SVMs for data classification offers both pros and cons. medical data sets can be non-linear and high-dimensional based on observed attributes. SVM remains a popular alternative for classification. SVMs offer several advantages for categorisation.

1. Regularisation parameters help avoid overfitting, a major concern in decision trees.
2. By utilizing kernel knowledge, the kernel tree is used to circumvent the need for specialized knowledge.
3. Convex optimization problem (COP), which SVM uses and lacks local minima, makes it an efficient method.
4. Error ratings are assessed to provide stronger assistance after dataset misclassification. All of these traits can be useful for medical diagnostic datasets, helping to design more efficient doctor prediction systems. However, while the benefits are great, there are some drawbacks. Decision trees, like any tools, have advantages and disadvantages. The method of reducing the overfitting problem is difficult, requiring careful parameter optimisation. Any fault in this optimisation can cause errors and increase overfitting.

K- NEAREST NEIGHBOUR ALGORITHM (KNN)

K-Nearest Neighbours (KNN) takes more time to train than other algorithms. Like other classification algorithms, KNN has two stages: training on the dataset and testing on new examples. KNN works by assigning weights to each data point, also known as neighbours.

For every K nearest neighbor, KNN determines the distance between data points in the training dataset. Classification is then established by the majority vote of these neighbours. KNN uses three types of distances: Euclidean, Manhattan, and Minkowski, with Euclidean being the most prevalent. The formula used to determine these distances [10]:

$$\text{Euclidean Distance} = D(x,y) \quad (1)$$

$$= \sum_{k=1}^K (x_k - y_k)^2$$

K= no. of cluster





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X, y = co-ordinate sample spaces

Manhattan distance = $\sum_{i=1}^n (x_i - y_i)$ (2)

X & y are co-ordinates

Minkowski distances are generally Euclidian distance

$Min = (\sum_{i=1}^n |x_i - y_i|^p)^{1/p}$ (3)

In KNN, samples are grouped according to their respective classes. When samples are grouped properly, they become smaller and can be utilized for training in the future. A larger K value typically produces results that are more accurate and less noisy, so choosing the right value is crucial. The algorithm for KNN is defined in the following steps.

1. The number of nearest neighbors is denoted by k , and the training samples are represented by D . Make each sample class a superclass.
2. Determine the Euclidian distance for every training set.
3. Use the majority of nearby classes to classify the sample.

DEEP LEARNING FOR PREDICATION IN HEART DISEASE

A branch of ML called DL focuses on learning at multiple levels of abstraction and representation, with multiple processing units for simultaneous processing at the input and output layers at each level [10]. The concept of feature hierarchy, which holds that lower-level information can be combined to generate higher level hierarchy, is the basis for deep learning. Models of neural networks are being revitalized by deep learning. Many efforts are being made to put them into practice through the use of automatic encoder-decoder methods and stacking restricted Boltzmann machines [11]. This method has impressed academics with its image processing performance, and layer-wise pre-training Recurrent Neural Networks (RNNs) function well with sequential features and data. Hochreiter and Schmidhuber's Long Short-Term Memory (LSTM) networks [12] outperformed other techniques designed for sequence-based tasks. Gated Recurrent Unit (GRU) is another contemporary method that yields remarkable results but is simpler than LSTM. For example, a study described in paper [13] used GRU to predict temporal-based heart disease with great accuracy. In the medical field, researchers are increasingly using deep learning algorithms on medical datasets. To quantify serum uric acid levels, for instance, Lasko et al. [14] used an encoder-decoder scheme. Analogous research has thoroughly examined this tactic. In the flowchart, there are five distinct modules, each with its specific operations. Here's a general overview of the process:

1. **Data Collection:** This initial phase involves gathering datasets from standard repositories.
2. **Pre-Processing:** This stage includes noise reduction and feature selection to prepare the data for further analysis.
3. **Deep Learning Core:** This critical module implements the core algorithmic approaches for manipulating the dataset. Algorithms may vary, ranging from Deep Belief Networks [15] to Recurrent Neural Networks (RNNs).
4. **Performance Analysis:** This module evaluates and compares the performance of the different existing methods used in the DL core.
5. **Discovery of Knowledge:** The final module gives desired outcomes, such as event likelihood. In this case, it determines the likelihood of a patient suffering a heart attack.

ANALYSIS OF AVAILABLE LEARNING ALGORITHM

Comparing two or more machine learning algorithms can be challenging due to the inherent differences between them. The difficulty arises because algorithms are highly dependent on the dataset they are applied to, making it hard to definitively determine which algorithm performs best for a given dataset. Implementing an algorithm in practice is the only trustworthy technique to determine its efficiency for a given dataset. To understand the distinctions between different ML techniques, a comparison is necessary. These comparisons might be very valuable for new researchers in the subject. This paper seeks to provide significant insights and help for novices to the subject by identifying key variances in performance across diverse contexts. Training the Naive Bayes classifier on a short dataset is quite simple due to its high bias and low variance. This feature offers it an edge over classifiers with low bias and high variance as KNN, which are prone to overfitting. Naive Bayes converges quickly, using less training





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data and effort. However, as the dataset size increases, Naive Bayes may encounter asymptotic errors. Algorithms with low bias and variance are better suited to handling such problems. One significant disadvantage of the Naive Bayes method is its inability to learn interactions between features. In contrast, logistic regression models are better at handling related features. Logistic regression also offers a strong mathematical probabilistic framework. However, it suffers with non-linear data and necessitates extensive feature manipulation before feeding the input into the model, which can be inconvenient. Despite this, logistic regression is user-friendly for updates, particularly with linear features. It performs well with online and temporal datasets, allowing it to adapt effectively to new rows and columns over time. The DT is a non-parametric machine learning algorithm known for its simplicity and ease of interpretation, making it valuable for understanding both the internal and external architecture of the model. However, decision trees have notable drawbacks, including a lack of support for online learning and susceptibility to overfitting. Techniques like the J48 model can help mitigate overfitting.

Ensemble methods such as Random Forest [16] address several issues inherent in decision trees, including handling imbalanced datasets, pruning, and improving accuracy. Random Forest combines multiple decision trees to enhance performance, but it may sacrifice some of the interpretability and compressibility of individual decision trees. Despite this, Random Forest is often considered a powerful alternative, capable of replacing many other machine learning algorithms in terms of accuracy. The DT valued for their interpretability, making them easy to explain both internally and externally. However, they have some significant drawbacks, such as lack of support for online learning and susceptibility to overfitting. Techniques like the J48 model can help mitigate overfitting issues. Ensemble methods like Random Forest (RF) [16] address several limitations of decision trees, including handling imbalanced datasets, pruning, and improving accuracy. RF combines multiple DTs to enhance performance but may lose some of the decision tree's interpretability and compressibility. The SVM and Neural Networks (NN) are major competitors in machine learning, both aiming at classification or regression but differing significantly in their approaches.

SVM

It is based on algebraic and statistical theory and divides classes significantly using a linear separable hyperplane in an n-dimensional space. SVM has the potential to achieve very high accuracy on multidimensional datasets. It converges on global and unique minima, providing a solid mathematical foundation and geometric representation. SVM is less affected by the dimensionality of the dataset than ANN.

ANN

A non-linear model with different characteristics compared to SVM. While SVM converges to global minima, ANN can converge to local minima. ANN's complexity often depends on dataset dimensionality, and it lacks a clear geometrical representation. However, ANN is generally more adaptable for online training and handles natural language processing (NLP) tasks better, as it scales linearly with the number of features compared to the exponential time complexity of SVM for high-dimensional data. Despite its advantages, SVM has limitations, such as being memory-intensive and challenging to tune. It is also less effective for training on NLP datasets due to the large number of features that can increase time complexity exponentially. In contrast, ANN performs well with online training and handles large feature sets more efficiently. A comparative table detailing the parameters, advantages, and disadvantages of each algorithm is provided below, reflecting their performance across various criteria.

CONCLUSION

Heart attacks are a serious health concern that affects many people around the world. This study summarises current methodologies and methods for forecasting this condition. The DL is a fast-developing subject in AI, has shown promise in making accurate medical diagnosis. However, its application in heart disease prediction remains an open question with room for future investigation. In addition to traditional ML algorithms, the research introduces several DL techniques for heart disease prediction. To find out which approach is better for medical datasets, an analytical



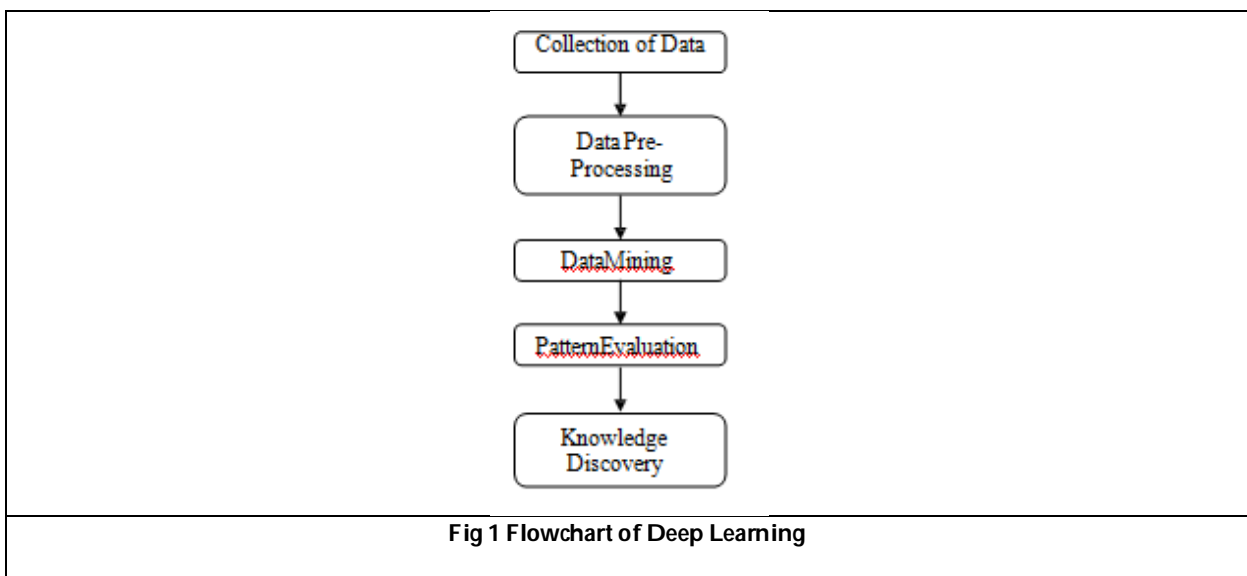


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comparison is provided. Looking ahead, we hope to expand this work to temporal medical datasets, where the data evolves over time and requires periodic retraining to retain accuracy.

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Real Time Weather Monitoring System using IoT

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ABSTRACT

The Internet of Things, or IoT, has completely changed the way we work and live while also opening up new avenues for weather monitoring. Conventional weather reporting systems depend on labor-intensive and error-prone human data collection techniques. Real-time meteorological data may be gathered, examined, and wirelessly communicated with IoT technology, offering precise and timely information for a range of use cases. The constantly changing environment has resulted in unpredictable weather conditions. As a result, the Weather Reporting System is used to monitor and control weather in many areas such as residences, industries, and agriculture. Microcontrollers, software, and sensor devices allow for autonomous protection and monitoring in a "smart environment." Sensors and weather stations are examples of IoT devices that can be put strategically in various locations. They gather information on precipitation, wind speed, temperature, humidity, and other meteorological factors. These gadgets send data wirelessly to a central location for analysis and processing.

Keywords: Internet of Things (IoT), Liquid Crystal Display (LCD), Organic Light Emitting Diode (OLED).





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INTRODUCTION

One of the largest problems in today's world is measuring the live environmental condition because there are a lot of obstacles that arise. Since the suggested method tracks current weather conditions, it will solve this issue. We shall monitor the various cities live weather parameter as part of the suggested activity. Using Internet of Things, The suggested system will be built on a client-server architecture. The system is structured using a two-tier architecture. Our proposed system includes a variety of sensors that will monitor the area temperature, humidity, precipitation, and system pressure. The data gathered by the Sensor was transmitted to the node MCU controller. The Arduino IDE can be used to upload the sensed data. Connecting a sensor to the cloud, the serial monitor has served as a conduit. A serial monitor receives data that is pushed by the sensor. One IP address is tracked by the serial. Viewing the data on the web server requires the HTTP protocol. In this work, environmental parameters or sensors are used to Monitor weather data in real time and display the data on a webpage. Anybody, wherever, may keep an eye on the weather conditions using a web server—they don't need to rely on any specific app or website. Public access to the data is accessible. We quantify the weather in various Regions using this suggested system. Upon obtaining data from several sensors, it has been observed that our suggested model outperforms the industry standard weather parameter. Every person's existence involves a great deal of weather monitoring. Environmental issues arise in a variety of industries, including building and agriculture. However, the majority of the measurable impact is concentrated in industry and agriculture. Agriculture is well acknowledged to play an important role in the Indian economy [1]. Agriculture accounts for more than one-quarter of India's GDP. Smart agriculture has been a popular topic of conversation around the world over the last year. The smart word in IoT implies that employing the fewest feasible parameters gives superior results. It lessens the amount of land, water, time, and new technology and research needed to improve crops [2]. One of the main problems with IoT networks is security. There are various strategies for enhancing security, but there are still many opportunities to do so [3].

LITERATURE REVIEW

The performance of weather tracking systems can be difficult to determine because it depends on a number of variables and how individual system components work. To evaluate its performance, a real-time surveillance system is needed. This paper provides an overview of Internet of Things applications for real-time performance monitoring and control of weather tracking systems. The farming process in agriculture has multiple stages prior to the yield, and weather has a significant influence on these phases. Rainfall is primarily experienced in the various Region. The location is close to the Indian border with Nepal, an area characterized by hills, which is the main cause of precipitation [4]. The excessive rainfall that results from this condition is a concern for farming. Predicting the weather before planting or harvesting the crops is crucial in this case. Thus, in this scenario, weather monitoring systems would be helpful to farmers in tracking the conditions of the weather. Our system's primary goal is to tell farmers whether doing so would be useful before they plant or harvest their crops [5]. An Internet of things-based weather monitoring system is presented by the author in [6]. Sensors in this study can be utilized to obtain environmental parameters. In addition to the LDR sensor, the author uses an additional sensor to monitor humidity, temperature, pressure, and rain value. The temperature prototype is used by the system to determine the dew point value. Any location, even a specific room or region, can have its value measured using a temperature sensor. Utilizing the light intensity as the author suggests is possible with the aid of the LDR sensor. The author [7] includes an additional weather monitoring function, an SMS alert system, which is activated when temperature, humidity, pressure, light intensity, and rain value exceed predefined criteria. The author also includes a mechanism for tweet posts and email notifications. The author of this system employs numerous sensors as well as a node MCU 8266. In this paper [8], the author utilizes an OLED display to demonstrate a low-cost live weather monitoring system, emphasizing the various fields where IoT innovation has resulted in unique system advancements. The writer expounded upon a novel and innovative framework. It gauges the current state of the weather in real time. Everyone can benefit greatly from weather monitoring, including farmers, businesses, regular workers, and students.





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Therefore, the author lessened the challenge for farmers and industry by creating a live weather monitoring system. The author of [9] An OLED panel was used to display the current weather. The author's suggested technique involved receiving data from the cloud using an Arduino-powered WeMos D1 board with an ESP8266-EX microcontroller. The Wemos D1 wifi module was designed with the ESP-8266EX microprocessor. There is 4MB of flash memory on it. It's the best when you use the Node MCU and Arduino IDE together. The author of this research uses only two devices to measure the weather: Wemos and OLED. After the connection is made and the data is saved on the cloud, the weather information is shown on the Thing Speak website. In [10], the author presented a method for tracking and forecasting weather conditions so that anyone can make plans for their daily lives. This exercise proved beneficial in both industry and agriculture. The author employs two stages of the weather management system to accomplish weather information monitoring and prediction. The real-time weather reporting system in stations and buses is made possible by combining sensor data, bus mobility, and deep learning technology. The author [11] shows how to monitor the weather with IoT technology and how to build an IoT-based weather monitoring system. Which provide information on climate change-related issues. This endeavor can help people become more conscious of climate changes. It produces an accurate and effective output, which is then applied using the swarm method to improve accuracy even further. Thus, the author intends to employ IoT to develop a weather monitoring system. This paper [12] uses both software and hardware, which simplifies implementation. In the project, the climate data is gathered by the author using an alternative sensor and stored in the cloud. Internet of things projects frequently uses the website www.thingspeak.com for this storing. Additionally, using an API key, it retrieves all of the weather data from the cloud storage space and uploads it to the Android mobile application. The "Embedded weather station with Remote wireless control" is presented in this work [13]. The author of this paper goes into further detail about the significance of a weather monitoring system. The author explains how today's weather monitoring system operates. It is crucial to be aware of the weather before doing any specific job outside. The field in which weather monitoring is significant is described in this work [14]. Numerous solutions are available for tracking weather parameters in numerous fields, including agriculture, the military, entertainment, and enterprises. It explains the three options, including one for weather monitoring.

Artificial intelligence was used in the author's [15] conceptualization of the weather monitoring idea. The author claims that weather forecasting uses a static method rather than a binary decision idea. The author wants to put in place a sophisticated weather forecasting system. As a result of the system's required tool, which measures and analyzes the highest and lowest temperatures as well as the amount of rainfall during a sampled portion of the day Machine learning algorithms are used to generate the available data, which is the basis for the forecast. According to current research,[16] the system performed better and had greater accuracy when machine learning techniques were used. One area of artificial intelligence is machine learning. It has demonstrated that its technology for analysis and prediction is strong. Weather forecasting is one of the key fields where machine learning is used, along with other fields like industrial, agricultural, logistics, healthcare, and so forth. In this work, the outcome is confirmed by the use of an artificial neural network, or ANN, in conjunction with a logistic regression technique for multiclass classification [17]. The real-time accessible system is discussed by the author in [18]. In this work, the author suggested an IoT-based approach. The technology used in this study monitors elements of the weather and climate, including humidity, temperature, pressure, UV radiation, and even airborne carbon monoxide levels. Several sensors are used to gather data, which is then transmitted to a webpage where it is viewed and sensed data is shown visually. Information that has been uploaded to a web server is accessible from any location in the globe. A Smartphone application that notifies an alert system to notify people of abrupt and severe weather changes is the main component [19].

System Design and Implementation

Some of the ways IoT plays a key role in weather monitoring systems are:

- **Real-time Data Collection:** Conventional techniques for gathering data can be labor-intensive and slow. IoT allows sensors to continuously gather real-time data, giving a more accurate picture of the weather.



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- **Cost-effective:** When weighed against more conventional weather monitoring apparatus, IoT devices are comparatively inexpensive. This facilitates the deployment of several sensors in various areas for thorough weather monitoring by businesses.
- **Remote Monitoring:** IoT makes it possible to monitor weather remotely, doing away with the requirement for in-person data collection visits. This is especially helpful in places that are difficult to access or during severe weather.
- **Data Analytics:** Advanced analytics can be used to find patterns and trends in meteorological data with a lot of real-time data, improving weather forecasts.
- **Early Warning Systems:** Additionally, IoT can be used to set up early warning systems for extreme weather occurrences like floods, tornadoes, and hurricanes. This enables people and authorities to take the appropriate safety measures and lessen any harm.

Weather Monitoring System with IoT Block Diagram

Applications are divided into two categories: event detection-based and spatial process estimation. At the centre of the ecosystem is a microcontroller, such as Arduino UNO or ESP8266, which acts as the central hub. It orchestrates the connectivity of various sensors (such as humidity and temperature sensors) and devices, acting as the brain of the entire system. The collected data is promptly transmitted to the web server after establishing a stable connection between the server and strategically placed sensor devices [20]. Wi-Fi modules like Node-MCU are used to upload and store the processed sensor data on a website, serving as a reliable database the weather monitoring system using IoT block diagram is shown in Fig.(1). The web server page allows us to monitor and control the system.

- The inbuilt monitoring device provides data on humidity, temperature, and CO levels in the surrounding region.
- Collected data is stored on cloud storage.
- Cloud data can be used for parameter analysis and continuous observation.
- Recorded regular air temperature, humidity, and carbon monoxide levels.

Areas Benefit From Weather Forecasting System with IoT

- **Agriculture Sector**
Farmers can make educated judgments about crop selection, watering schedules, and pest management with the aid of weather forecasts. With real-time monitoring, farmers may receive precise data on plant development and soil moisture levels, guaranteeing the best possible crop output.
- **Transportation**
To prevent delays or accidents brought on by severe weather, real-time weather monitoring is essential for the transportation sector. Transportation companies may track road conditions and arrange routes accordingly by utilizing IoT-based sensors on cars and roadways.
- **Disaster Management**
Natural disasters like hurricanes, floods, and snowstorms can be predicted with the use of IoT-based weather monitoring systems. Authorities can limit harm by issuing timely warnings and taking necessary safeguards with the help of precise data.
- **Urban Planning**
Real-time weather data can help city planners manage infrastructure and resources more effectively. For example, by providing earlier notice of heat waves or heavy precipitation, they can plan emergency services appropriately and avert any calamities.
- **Tourism**
Tourism is significantly impacted by the weather, and passengers' experiences can be substantially improved with real-time weather monitoring. Weather forecasts that are accurate help travelers organize their activities, which makes for a more pleasurable and hassle-free trip.
- **Healthcare**





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Healthcare facilities must have access to real-time weather information in order to plan for severe weather or natural catastrophes. Hospitals can keep an atmosphere safe for patients by using IoT-based sensors to track humidity levels, air quality, and temperatures both inside and outside.

Types of sensors Involved in Weather Tracking System

Depending on the particular application, a wide variety of electronic sensors are used by weather monitoring systems. A Real time weather monitoring system is shown in Fig.(2) To increase agricultural productivity, for instance, farmers need data on a variety of variables, including temperature, relative humidity, soil moisture, and rainfall [21]. They use particular kinds of sensors to gather this information. Among the sensors of this type are:

- **Temperature sensor:** determines the temperature of the surrounding air.
- **Humidity/hygrometer sensor:** finds and gauges the environment's humidity level.
- **Soil moisture sensor:** keeps an eye on the soil's moisture level.
- **Rain sensor:** detects and gauges the amount and strength of precipitation. An airplane pilot is another example, who has to obtain vital data before to takeoff, including wind direction, speed, atmospheric pressure, precipitation, and visibility. Pilots use a range of sensors to get this crucial facts.
- **Barometric sensor:** This device gauges detect atmosphere air pressure values.
- **Anemometer:** Gets wind speed information.
- **Rain Sensor:** Identifies and gauges precipitation.
- **Visibility sensor:** Determines visibility in inclement weather, including storms, rain, and snow. IoT-based weather monitoring system in the future more sophisticated and creative solutions should be forthcoming as IoT is being used more widely across a range of industries, including weather monitoring. Among the

Potential outcomes are:

- **Accurate forecasting**
IoT-based weather monitoring systems will be made possible by advances in data analytics and technology. The forecasts produced by these algorithms will be increasingly more precise.
- **System integration**
It is possible to link IoT-based weather monitoring systems with other systems. The capabilities of these systems are increased by the inclusion of smart cities and households. A smart home might, for instance, modify its temperature settings in response to current meteorological information [22].
- **Machine learning**
IoT-based weather monitoring systems may continuously learn from historical data by utilizing machine learning algorithms. As a result, they can gradually get better at predicting.
- **Improved disaster management**
Real-time meteorological data can be sent to disaster management authorities by means of Internet of Things (IoT)-based sensors. They are able to safeguard the public by Taking the appropriate measures as a result.
- **Customized notifications**
Internet of Things (IoT)-based weather monitoring devices enables individuals to receive customized weather alerts. Better planning and safety are ensured by these location- and preference-based alerts. IoT technology has enormous promise and value for weather monitoring, and this potential will only increase with time [23]. By deploying IoT-based weather monitoring systems across several industries, we can significantly boost productivity and efficiency while lowering the hazards related to erratic weather patterns.

RESULT ANALYSIS

This research paper suggests a real-time, affordable weather tracking system using an Arduino. Weather tracking production may be measured with this system temperature, humidity. There was weather module monitoring done. These outcomes were attained using a system that included sensors, software, and a microcontroller. The software





that makes use of the present sensor is far more user-friendly. The various reading are measured like temperature (T), humidity (h) with the help of weather tracking system.

CONCLUSION

IoT solutions improve crop management and reduce weather-related hazards by giving farmers precise data on soil moisture and climate. IoT weather stations continuously track and report conditions in harsh environments, such as volcanoes and rainforests, providing essential information for study and safety. Our ever-volatile global climate emphasizes how crucial sophisticated, real-time monitoring systems are. Thanks to IoT developments, businesses may now employ advanced analytics to lessen the negative effects of weather on operations and business. Discover the ways that Ariel's IoT solutions are benefiting different global sectors.

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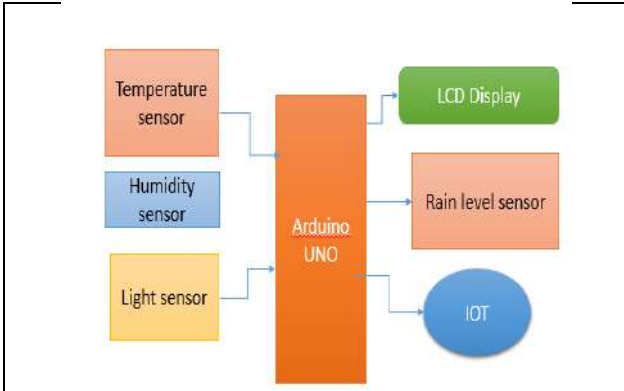


Fig. 1. Circuit Diagram of Weather monitoring System



Fig.2 IoT Weather tracking system





Diabetes Mellitus Risk Level Prediction using Machine learning Algorithms Compared with Rule based K- Means Algorithms

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ABSTRACT

Diabetes mellitus is one of the critical health issues all over the world. Prediction and prevention of diabetes mellitus is certainly important in order to avoid other chronic diseases. It may leads to heart disease, kidney failure, nerve damage, blood vessel damage, lower limb amputation and blindness. So mining the diabetes patient data effectively will help to predict the risk level of diabetes victim. This work proposes Rule Based K-Means algorithm to predict the risk level of diabetes victims. In this work two different types of approaches have been proposed for clustering the patient record namely insulin dependent patients and tablet dependent patients. The proposed algorithm is compared with various prime algorithms like Support Vector Machine, Naïve Bayes, ID3 and Random Forest tree. The experimental results prove that Rule Based K-Means provides highest accuracy than other algorithms.

Keywords: SVM, Naïve Bayes, Random Forest tree, ID3, Rule Based K-means

INTRODUCTION

Diabetic Mellitus is endless ailment that is portrayed by high blood glucose level. About portion of the considerable number of diabetics have family heredity factors, which is one of the highlights in diabetic mellitus. Disappointment of pancreas to deliver enough insulin and the body's wasteful utilization of insulin are both pathologic foundations for diabetic mellitus. There are primarily four sorts of Diabetes Mellitus. They are Type1, Type2, Gestational diabetes



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and innate diabetes. Diabetes mellitus affected patients' prediction to help the patients to overcome the risk levels of the other chronic diseases. The use of clustering technique in medical diagnosis is increase gradually. There is no doubt in that evaluation of data taken from patients through labs and decision of expert are most important factor in diabetes mellitus diagnosing. But expert system and Artificial intelligence techniques for clustering and classification also help expert in great deal. Most of the work related to machine learning in diabetes diagnosis is concentrated to diabetes dataset. In this work diabetes mellitus affected patient risk level prediction was implemented in different clustering and classification algorithms and the performance measures are evaluated. In this paper clustering and classifier techniques with Rule Based K-Means algorithm are implemented for the forecasting of diabetes mellitus risk levels and concludes the best algorithm which produces maximum accuracy levels. The implementing techniques are Rule Based K-Means with Support Vector Machine, Naïve Bayes, ID3 and Random Forest tree. The residual investigation discourse is sorted out as pursues Section-II Dataset used, Section-III Methodology utilized and diverse procedure of dataset. Section-IV states assessed results. Section-V Conclusion of my investigation work.

LITERATURE REVIEW

According to the World Health Organization (WHO) there are 350 million people affected diabetes mellitus and diabetes will become the seventh leading cause of death worldwide by 2030. It will be estimated to increase in 2050 by 50% of the people in the next 10 years. The number of diabetic person is increases in every country, 4 out of 5 people live with diabetes with low and middle in countries and half of diabetics don't they are affected from these disease. This global epitomic could be largely attributed to the rapid increase in the rates of overweight, physical inactivity, not maintain proper foot diet. P. Thangaraju and B.Deepa [3], proposed a survey on preclusion and discovery of skin melanoma risk using clustering techniques. The skin melanoma patient's data are gathered from different diagnostic centre which contains both cancer and non-cancer patient's information. The gathered data are pre-processed and then clustered using K-means algorithm for separating relevant and nonrelevant data to skin melanoma. Dr.N. Rajalingam, K. Ranjini [16], presented a comparative study of implementation of hierarchical clustering algorithms- agglomerative and divisive clustering for various attributes. The Visual Programming Language is used for implementation of these algorithms. The result of this paper study is the performance of divisive algorithm works as twice as fast as the agglomerative algorithm. The research paper [4] developed a method using combined dataset of Diabetes disease. Here select (accuracy- 63.54%, specificity- 43.00%, and sensitivity- 99.80%), wrapper (accuracy- 70.69%, specificity- 38.36% and Sensitivity- 89.95) and Ranker (accuracy- 72.61%, specificity- 41.04%, and sensitivity- 90.76%) methods are used for feature selection and LIBSVM for classification feature.

DATASET USED

The dataset which is used in this study contains five records collected from various labs. The dataset are pre-processed and the measurements are calculated and compared. The following attributes are taken to evaluate the proposed methodologies, Person, HbA1c, FBS, PPBS, Age and Mode of treatment (Insulin/Tablet). The variables HbA1C, FBS and PPBS was the most strongly associated with type2 diabetes than other variables like person, gender, number of years affected. The above tabel1 contains the dataset and attributes are as follows name, age, gender, type1/2, hba1c,fbs, ppbs, medicine taken insulin or tablet and number of year affected the patients the values are specified in the table.

METHODOLOGY

The proposed Rule Based K-means algorithm is used for predicting the diabetes mellitus with improved accuracy when compared to Support Vector Machine, Naïve Bayes, ID3 HA FCM and Random Forest tree algorithms. The following section describes the working model of the algorithm and existing algorithms. Datasets of name, age, gender, FBS, PPBS, HbA1C, No of years affected, and the medicine in-take either Tablet or Insulin of patients are collected from various labs. The person details such as FBS level, PPBS level, HbA1c level, the person affected in





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years by this disease are all available in the dataset. The Preprocessing techniques were implemented with help of class order technique and some of the fields are removed e.g. Gender, No of years affected and some fields are masked from the identity like name with person1,2,...,n and the preprocessed dataset are taken and the proposed algorithm is applied and various measures are registered. The other clustering algorithms Decision Tree, Hierarchical Algorithm, Fuzzy C Means, and Naive Bayes and SVM algorithm are also applied on the dataset for process to record for various measures and are compared with proposed Rule-Based K-Means algorithm measures. The performance measures that are recorded are accuracy, precision, recall and f-measures and are used in clustering algorithms. The results of the comparison with proposed algorithm are enlisted and charted.

Accuracy Measures

Rule Based K-Means Algorithm, Decision Tree, SVM and Naive Bayes algorithms are used in this research work. Investigates are achieved by internal cross-validation 10-folds. Accuracy, Sensitivity, Specificity F-Measure, and ROC processes are regained for the classification of this work. Below Table-2 and 4 defines accuracy measures.

Attributes used

The following attributes are used to find the accuracy measures as follows Person, HbA1c, FBS, PPBS, age and Mode of treatment (Insulin/Tablet)

Proposed Rule Based K-Means Algorithm (RBKM)

The proposed Rule Based K-Means Algorithm for prediction of risk level of diabetes mellitus involves with the approach of partitioning of the dataset into clusters with different irrelevant groups. Each group contains any number of data. Then the initial center node is selected arbitrarily and the numbers of groups are not selected and not known in advance. The number of groups is identified based on the way of treatment the patients. Undergoing the patient treated using only tablet and patient treated only in insulin are the two groups in the dataset. Then the center nodes that are identified by selecting one from insulin patient and another from tablet patient. Then the algorithm separates the dataset by measuring not only the squared Euclidean distance but also using the group formation rules that are framed based on the parameters such as HbA1C, FBS, PPBS, AGE.

Rule Based K-Means Algorithm Steps

- Step 1.** Identify the two dependent variable from the dataset.
- Step 2.** Form the scatter diagram based the dependent variables x and y.
- Step 3.** Label all the data points in the scatter diagram. Assign the number of groups=2.
- Step 4.** Identify two Initial Center Value (ICV) values randomly based on the mode of treatment (Insulin or Tablet).
- Step 5.** Determine all the nearest nodes of the ICV using distance formula.
- Step 6.** By suppression and iteration, select the number of data points in a group based on the lowest distance between the data point and ICV. The data points can be selected for the group until the highest calculated value/2.
- Step 7.** When all the nodes have been assigned either of the groups, recalculated the passion of ICV values.
- Step 8.** Derive new ICV.
- Step 9.** Repeat step 5 to 7 until the ICV reaches fixed position. This produces a separation of the dataset into groups, from which the metric to be minimized can be calculated and goto step 10.
- Step 10.** The following conditions are used to frame the optimized group from the previous steps.

Group Formation Rules

Rule 1: X (Suggestion="Insulin") = (HbA1C>=7) && ((FBS>125) || (PPBS>105)) &&(AGE>50)

Rule 2: X (Suggestion="Tablet with WALKING") = (HbA1C>7) && ((FBS>125) || (PPBS>105)) || (AGE<50).

Rule3: X (Suggestion="Insulin or Tablet with WALKING and Diet") = (HbA1C<7) && ((FBS<125) || (PPBS<105)) &&(AGE>50)

Rule4: X (Suggestion="Tablet with WALKING") = (HbA1C<7) && ((FBS<125) || (PPBS<105)) && (AGE<50)

Rule 5: X (Suggestion = " Insulin or tablet with WALKING") = (HbA1C>7) && ((FBS<125) || (PPBS<105)) && (AGE>50)



**Krishnamoorthy et al.,****Description for Group formation Rules**

Rule 1: For age above 50 and HbA1c is greater than or equal to 7 and FBS or PPBS is greater than 125 or 105 respectively then the Suggestion is Insulin.

Rule 2: For age below 50 or FBS is greater than 125 or PPBS is greater than 105 and HbA1c is greater than 7 then the Suggestion is Tablet with Walking.

Rule 3: For age above 50 and HbA1c is less than 7 and FBS or PPBS is less than 125 or 105 respectively then the Suggestion is Insulin or Tablet with Walking and Diet.

Rule 4: For age below 50 and HbA1c is less than 7 and FBS or PPBS is less than 125 or 105 respectively then the Suggestion is Tablet with Walking.

Rule 5: For age above 50 and HbA1c is above 7 and FBS or PPBS is less than 125 or 105 respectively then the Suggestion is Insulin or Tablet with Walking.

RESULT AND IMPLEMENTATION**Rule Based K-Means with Naive Bayes SVM ID3 and Random Forest Tree****Naive Bayes**

Naive Bayes is a characterization procedure with a thought which characterizes all highlights is independent and random to one another. It characterizes that status of a particular component in a class not ensure influence the status of another element. Since it depends on contingent likelihood it is considered as an amazing calculation utilized for arrangement reason. It functions admirably for the information with unbalancing issues and missing qualities. It is a machine learning classifier which utilizes the Bayes Theorem. Utilizing Bayes hypothesis back likelihood $P(C/X)$ can be determined from $P(C)$, $P(X)$ and $P(CX)$.

Support Vector Machine (SVM)

Support vector machine is the simplest, linear form, and it is a hyperplane that separates a set of positive examples from a set of negative examples with maximum margin. In the linear case, the margin is defined by the distance of the hyperplane to the nearest of the positive and negative examples. It is one of the regular arrangements of directed machine learning standard utilized in characterization. Given a two-class preparing test the point of a help it is to pinpoint the best most noteworthy edge detachment hyperplane among the dual classes. For better conjecture, hyperplane ought not to lie nearer to the information focuses have a place with the different class. Hyper plane ought to be chosen which is a long way from the information exertions from every class. The focuses that untruth nearby to the pinpoint of the classifier are the help vectors.

Random Forest Tree (RFT)

Random Forest is a popular machine learning algorithm that belongs to the supervised learning technique. It can be used for both Classification and Regression problems in Machine Learning. It is based on the concept of ensemble learning, which is a process of combining multiple classifiers to solve a complex problem and to improve the performance of the model. It is a classifier that contains a number of decision trees on various subsets of the given dataset and takes the average to improve the predictive accuracy of that dataset. Instead of relying on one decision tree, the random forest takes the prediction from each tree and based on the majority votes of predictions, and it predicts the final output. The greater number of trees in the forest leads to higher accuracy and prevents the problem of over fitting.

ID3 Algorithm

The ID3 algorithm is a popular decision tree algorithm used in machine learning. It aims to build a decision tree by iteratively selecting the best attribute to split the data based on information gain. Each node represents a test on an attribute, and each branch represents a possible outcome of the test. The leaf nodes of the tree represent the final classifications. In the above table 3 describes the proposed Rule Based K means algorithm and existing





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algorithm are Support Vector Machine, Naïve Bayes, ID3 and Random Forest tree confusion matrix values are evaluate and tabulated. The above Table-4 describes the Accuracy measure for five algorithms namely, Rule Based K-Means algorithm (97.30%), SVM (94.5%),RFT (93.3%), ID3 (93.20%), Naïve Bayes (92.30%). Precision measures for five algorithms Rule Based K-Means algorithm (0.500), Naïve Bayes (0.500%) and ID3 (0.500%), SVM (0.480), RFT (0.475). The Recall measures for the five algorithms Rule Based K-Means algorithm (0.500%), RFT(0.425), SVM(0.450) ,Naïve Bayes (0.125%) and ID3 (0.333%). And the F-measure for five algorithms namely, Rule Based K-Means algorithm (0.500%), SVM(0.481),RFT(0.465),Naïve Bayes (0.200%), and ID3(0.391%).

Rule Based K-Means with Hierarchical ,Fuzzy C Means

Hierarchical clustering

It divides datasets into clusters in a sequential manner with nested in proportions. By the method of analyses, groups are hunted to construct a hierarchy of clusters. A tree data structure called a Dendrogram can be used to illustrate the hierarchical clustering technique with the sets of different clusters. The root in a Dendrogram contains one cluster from which all other clusters are hierarchically become nodes until leaves in a Dendrogram that each node consist of a single element cluster. Internal nodes represent new cluster formed by merging the cluster that appears as its children. Each level is associated with the distance measure that was used to cluster. The following steps of process are applied for hierarchical clustering:

Fuzzy C-means clustering

It is a method of clustering that allows an object to belong to two or more clusters. This method is frequently used in pattern recognition. Basically, this algorithm works by assigning membership values to each object corresponding to each cluster center on the basis of distance between the center of the cluster and the object. The nearer the data point is to the cluster center, more is the membership towards the cluster of center. The summation of membership values of each object should be equal to one and also, the number of clusters needs to be specified in the beginning. But, unlike k-means where objects must exclusively belong to one cluster center here objects are given belongingness to each cluster center as a result of which objects may belong to more than one cluster center. The following steps are processed in fuzzy C means algorithm to perform the cluster of diabetes mellitus patient datasets. In the above table 5 describes the proposed Rule Based K means algorithm and existing algorithm are fuzzy C means, hierarchical confusion matrix values are evaluate and tabulated. The above Table-6 describes the Accuracy measure for algorithms namely, Rule Based K-Means algorithm (97.30%), Hierarchical Algorithm (94.30%), Fuzzy C Means (93.00%). Precision measures for algorithms Rule Based K-Means algorithm (0.500), Hierarchical Algorithm (0.490), Fuzzy C Means (0.485). The Recall measures for the algorithms Rule Based K-Means algorithm (0.500%), Hierarchical Algorithm (0.460), Fuzzy C Means(0.450). And the F-measure for algorithms namely, Rule Based K-Means algorithm (0.500%), Hierarchical Algorithm (0.481), Fuzzy C Means(0.465).

The above Figure-4 describes the Accuracy measure comparison for seven algorithms namely, Rule Based K-Means algorithm (97.30%), SVM (94.50%), RFT(93.3), ID3 (93.2) Naïve Bayes (92.30%) , Hierarchical Algorithm (94.3%) and Fuzzy C Means (93).It shows that rule based k-means is as better than other six algorithms. Comparison between Precision measures for seven algorithms Rule Based K-Means algorithm ,Naïve Bayes ID3share the value (0.500),and minimum for RFT(0.475), SVM (0.48), Hierarchical Algorithm (0.49) and Fuzzy C Means (0.49). The Recall measures comparison for the seven algorithms Rule Based K-Means algorithm (0.500%), SVM (0.450), RFT(0.425), ID3 (0.333) Naïve Bayes (0.125) , Hierarchical Algorithm (0.46) and Fuzzy C Means (45). And the F-measure comparison for seven algorithms namely, Rule Based K-Means algorithm (0.500), Hierarchical Algorithm(0.481), Fuzzy C Means(0.465),Naïve Bayes (0.200%), and SVM (0.391%) RFT(0.465),ID3(0.391)and Rule Based K-Means were seen as better than the other seven. Figure-6, shows ROC area of five algorithms namely Rule Based K-Means algorithm (1.0%), SVM (0.95), RFT(0.94), ID3 (0.97) Naïve Bayes (0.96) , Hierarchical Algorithm (0.91) and Fuzzy C Means(90). It reveals the fact Rule Based K-Means algorithm is better than the other four. The minimal is Fuzzy C Means which is better than other seven.



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CONCLUSION

In this Research work, orderly endeavors are made in planning a framework which results in the method of forecast of treatment like Insulin or Tablet. During this work the proposed models are portrayed and contrasted with two processing are compared one four clustering algorithms on different measures and another work was processed with five clustering algorithms. Analyses are performed on clinical diabetes dataset. Exploratory outcomes decide the adequacy of the structured framework with an accomplished exactness of 97.3 % utilizing the Rule Based K-Means algorithm which yields better results than the Support Vector Machine, ID3, Random Forest tree ,Naive Bayes, Hierarchical Algorithm, and Fuzzy C Means algorithm. In future, the designed methodology for type2 identification processes can be a better solution for any similar clustering algorithms in different fields. This can also be incorporated in self-monitoring devices or applications.

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Table.1 Sample Preprocessed Dataset

S. No	Name	Age	Gender	Type 1/ 2	HbA1c	FBS (mg/dL)	PPBS (mg/dL)	No. Years affected	Medicine Insulin/Tab
1	p1	43	M	Type 2	6.8	122	100	6	Tablet
2	p2	46	M	Type 2	7.3	127	106	10	Tablet
3	p3	40	M	Type 2	6.7	121	104	7	Tablet
4	p4	49	F	Type 2	7.4	122	103	7	Tablet
5	p5	53	M	Type 2	6.9	124	100	13	Tablet
6	p6	50	M	Type 2	7.1	125	110	15	Tablet
7	p7	61	M	Type 2	7.9	123	108	17	Tablet
8	p8	54	M	Type 2	7	121	106	16	Tablet
9	p9	46	F	Type 2	7.5	125	100	8	Tablet
10	p10	56	M	Type 2	6.6	128	102	18	Insulin

Table 2. Accuracy Procedures

Events	Descriptions	Method
Accuracy(ACC)	Exactness decides the accuracy of the calculation in foreseeing examples.	$ACC=(TP+TN)/(TP+TN+FP+FN)$
Sensitivity(SN)	Classifiers rightness/exactness is estimated by Sensitivity.	$SN=TP/(TP+FP)$
Specificity(SP)	To quantify the classifiers culmination or sensitivity, Recall is utilized.	$SP=TP/TP+FN$
F-Measure	F-Measure is the weighted normal of precision and recall.	$F=2*(P*R)/(P+R)$
ROC	ROC (Receiver Operator Curve) arches are utilized to compare the helpfulness of tests.	

Table 3. Confusion Matrix of various Machine learning algorithms

	Rule Based K-Means		SVM		RFT		ID3		Naive Bayes	
Tablet	TN=95	FP=2	TN=92	FP=4	TN=91	FP=4	TN=92	FP=3	TN=89	FP=5
Insulin	FN=1	TP=2	FN=2	TP=2	FN=3	TP=2	FN=4	TP=1	FN=3	TP=3

Table 4.Performances of various Clustering System on Innumerable Methods

Clustering Algorithms	Precision(P)	Recall(R)	F-Measure	Accuracy (A)	ROC
Rule Based K Means Algorithm	0.500	0.500	0.500	97.30	1.00
SVM	0.480	0.450	0.481	94.50	0.95
RFT	0.475	0.425	0.465	93.30	0.94
ID3	0.500	0.333	0.391	93.20	0.97
Naive Bayes	0.500	0.125	0.200	92.30	0.96

Table 5. Confusion Matrix of various Machine learning algorithms

	Rule Based K-Means		Hierarchical		Fuzzy C means	
Tablet	TN=95	FP=2	TN=92	FP=3	TN=91	FP=4
Insulin	FN=1	TP=2	FN=3	TP=2	FN=3	TP=2

Table 6.Performances of various Clustering System on Innumerable Methods

Clustering Algorithms	Precision(P)	Recall(R)	F-Measure	Accuracy (A)	ROC
Rule Based K Means Algorithm	0.500	0.500	0.500	97.30	1.00
Hierarchical Algorithm	0.490	0.460	0.481	94.30	0.91
fuzzy C means	0.485	0.450	0.465	93.00	0.90



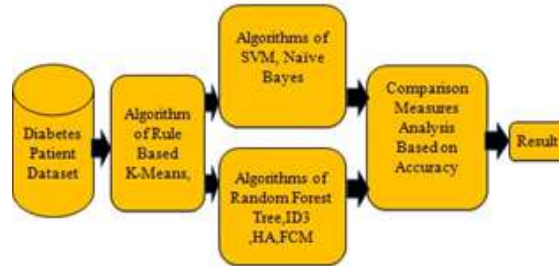


Figure.1. Model flow for comparison algorithms

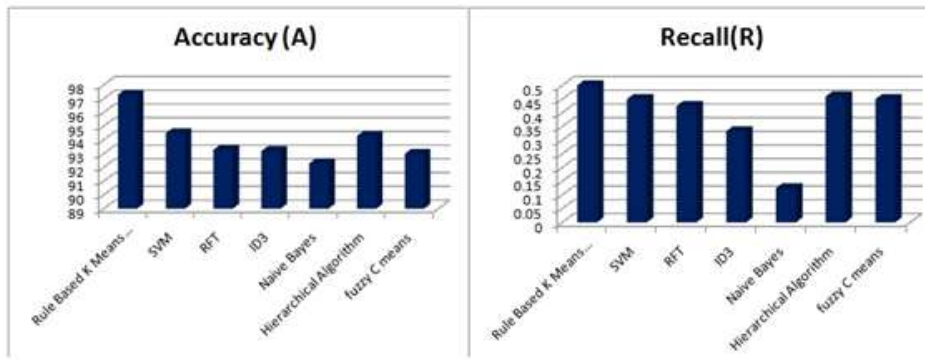


Figure 4. Classifier Performance Comparison on Accuracy and Recall Measures

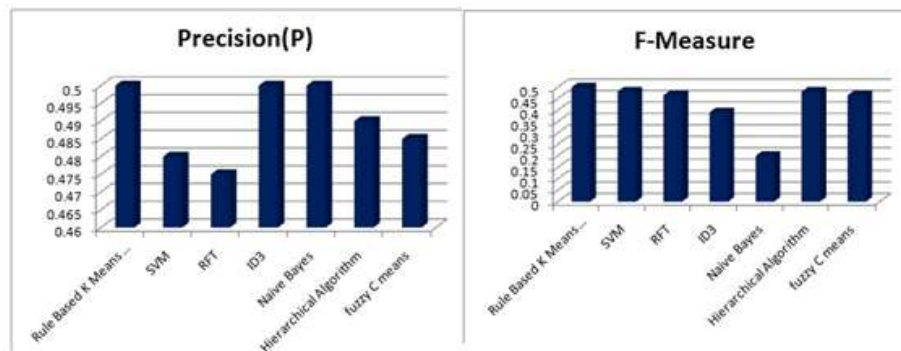


Figure 5. Classifier Performance Comparison on Precision and F-Measure

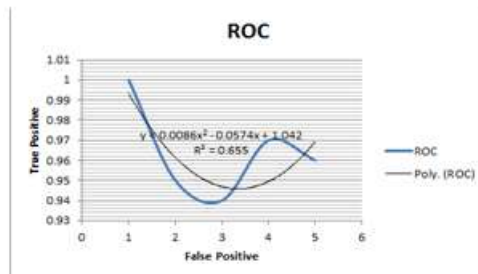


Figure 6. ROC Area of All Classification Algorithm





A Clinical Approach for Automated Kidney Stone Severity Prediction Using Deep Learning and CT Scan Images

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ABSTRACT

Kidney stone disease is a prevalent medical condition that can lead to significant discomfort and severe health complications if not treated promptly. The accurate and timely prediction of kidney stone severity is crucial for guiding appropriate clinical interventions. This study presents a novel automated approach for predicting kidney stone severity using deep learning techniques applied to computed tomography (CT) scan images. Our method leverages a convolutional Neural Network (CNN) architecture, trained on a diverse dataset of annotated CT scans, to accurately classify the severity of kidney stones into multiple categories based on size, location, and potential complications. The model is designed to assist clinicians by providing a reliable second opinion, thereby enhancing diagnostic accuracy and reducing the time required for assessment. This research work conducted extensive experiments to evaluate the performance of our model, achieving high accuracy, precision, and recall across various test scenarios. The proposed approach also includes a feature visualization component, enabling clinicians to understand the model's decision-making process, which is crucial for integrating AI-based tools into clinical practice. Our findings suggest that deep learning models can effectively augment clinical workflows in nephrology by providing fast, accurate, and non-invasive assessments of kidney stone severity, ultimately improving patient outcomes. This study lays the groundwork for future research into AI-driven diagnostic tools in urology and other medical specialties.

Keywords: kidney stone, Deep learning, severity prediction, computed tomography





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INTRODUCTION

Kidney stone disease, also known as nephrolithiasis, is a common urological condition characterized by the formation of hard, crystalline deposits within the kidneys. These stones are composed of minerals and salts that accumulate in the urinary tract, often due to imbalances in diet, dehydration, or genetic predisposition. The condition can affect individuals of all ages, but it is most prevalent among adults, with a higher incidence in men than in women. The impact of kidney stones on health can be significant. When stones obstruct the flow of urine, they can cause severe pain, typically referred to as renal colic, which is often described as one of the most intense types of pain a person can experience. In addition to pain, kidney stones can lead to complications such as urinary tract infections (UTIs), hematuria (blood in the urine), and, in severe cases, kidney damage or failure. Recurrent kidney stones are common, with about 50% of individuals experiencing another episode within five years of the first. From a healthcare perspective, kidney stone disease poses a considerable burden. The diagnosis, treatment, and management of kidney stones involve significant medical resources, including imaging tests, surgical interventions, and long-term management to prevent recurrence. The economic impact is also substantial, with high costs associated with emergency care, surgical procedures, and lost productivity due to the disabling pain and recovery time. Given these challenges, early detection and accurate assessment of kidney stones are critical for effective treatment and prevention of complications. Advances in imaging technology, particularly computed tomography (CT) scans, have greatly enhanced the ability to detect kidney stones. However, the interpretation of these images can be time-consuming and requires specialized expertise. This has spurred interest in developing automated tools that can assist clinicians in diagnosing and evaluating kidney stones more efficiently, potentially leading to better patient outcomes and reduced healthcare costs [9]. **Convolutional Neural Networks (CNNs)** have become a powerful tool in medical imaging due to their ability to automatically learn and extract features from images, making them particularly useful for tasks such as kidney stone severity prediction using CT scan images. Here's how CNNs contribute to this domain:

- Automated feature extraction
- High Accuracy in classification
- Localization and Detection
- Prediction of clinical outcomes
- Enhanced decision support
- Scalability and efficiency
- Interpretability and trust

CNNs excel at automatically extracting relevant features from raw image data without the need for manual feature engineering[1]. In the context of kidney stone severity prediction, CNNs can identify intricate patterns in CT scan images, such as the size, shape, density, and location of kidney stones, which are critical for assessing their severity. This automation significantly reduces the time and expertise required compared to traditional methods, where radiologists manually analyze these features. CNNs are well-suited for image classification tasks, and they can be trained to categorize kidney stones based on severity levels [2] (e.g., mild, moderate, severe) by learning from labeled datasets of CT images. The ability of CNNs to differentiate between subtle variations in image data allows for accurate classification of kidney stones, which is essential for determining the appropriate treatment strategy. For instance, larger stones or those located in critical areas may require surgical intervention, whereas smaller stones might be managed with medication or lifestyle changes. Advanced CNN architectures, such as those incorporating region-based networks (e.g., Faster R-CNN), can not only classify the severity of kidney stones but also localize them within the CT scan images [3]. This capability is crucial for clinicians, as it helps in precisely identifying the position of the stones within the urinary tract, which is important for assessing potential complications, such as blockages that could lead to kidney damage. By analyzing the features extracted from CT images, CNNs can be trained to predict clinical outcomes related to kidney stone disease [4]. For example, they can estimate the likelihood of stone passage, the need for surgical intervention, or the risk of recurrence. This predictive capability is valuable for personalized patient care, enabling clinicians to make informed decisions based on the predicted severity of the condition. CNNs can serve as decision support tools for radiologists and urologists by providing a second opinion in the diagnostic



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process. The output of a CNN model, such as the severity score or a heatmap indicating areas of concern, can complement the radiologist's assessment, leading to more accurate and consistent diagnoses. This collaboration between AI and clinicians can improve patient outcomes by ensuring that critical cases are promptly identified and treated [8]. The ability of CNNs to process large volumes of CT scan images quickly and accurately makes them highly scalable in clinical settings. Once trained, a CNN model can analyze new CT images in real-time, making it a valuable tool in hospitals and clinics where the timely diagnosis of kidney stones is crucial [5]. This efficiency also helps in reducing the workload on radiologists, allowing them to focus on more complex cases. Recent advancements in CNN technology include methods to enhance model interpretability, such as generating saliency maps that highlight the regions of the CT scan that the model used to make its predictions. This transparency is important for building trust among clinicians, as it provides insights into the model's decision-making process and allows for better integration of AI into clinical workflows. The methodology involved training a convolutional neural network (CNN) on a large dataset of annotated CT scan images. The images were preprocessed to enhance relevant features, and the model was fine-tuned using transfer learning techniques. Finally, the trained model was validated on a separate test set to evaluate its accuracy and reliability in predicting kidney stone severity. Deep learning models have shown remarkable accuracy in predicting the severity of kidney stones from CT scan images. These models can analyze complex patterns in the data that might be missed by traditional methods, leading to more precise diagnoses. As a result, they hold significant promise for improving patient outcomes through early and accurate detection. Early detection of kidney stones is crucial as it allows for timely treatment and can prevent complications such as severe pain, infection, and kidney damage. By using deep learning algorithms to analyze CT scan images, doctors can quickly and accurately determine the severity of the condition. This enables them to provide appropriate and effective treatment plans, improving patient outcomes and reducing healthcare costs.

LITERATURE SURVEY

The application of deep learning, particularly Convolutional Neural Networks (CNNs), to medical imaging has seen rapid advancements in recent years. In the context of kidney stone severity prediction, several studies have explored the use of CNNs to automate the detection, classification, and analysis of kidney stones using CT scan images [10]. This literature survey highlights key contributions in this area, focusing on methodologies, datasets, and the clinical relevance of these approaches. Early work in the application of CNNs for kidney stone detection focused on the basic task of identifying the presence of stones in CT images. For instance, Zhang et al. (2018) proposed a deep learning framework that utilized CNNs to detect kidney stones in non-contrast CT scans. Their model demonstrated high sensitivity and specificity, highlighting the potential of CNNs in reducing the diagnostic workload for radiologists. Similarly, Baghdadi et al. (2019) developed a multi-class CNN model that not only detected the presence of kidney stones but also classified them based on size and location. This approach marked a significant step towards more detailed analysis, enabling a more comprehensive understanding of the stone's characteristics, which are critical for determining the appropriate treatment. Recent studies have shifted focus from mere detection to the prediction of kidney stone severity, an essential factor in clinical decision-making. Cheng et al. (2020) introduced a deep learning model designed to assess the severity of kidney stones by analyzing the size, density, and potential complications visible in CT scans. Their CNN architecture was trained on a large dataset of annotated CT images, allowing the model to predict whether a stone would likely cause obstruction or require surgical intervention. Moreover, a study by Kim et al. (2021) integrated CNNs with clinical data to enhance the prediction of stone-related complications. By combining image-based features with patient-specific information such as age, gender, and medical history, the model achieved improved accuracy in predicting the need for invasive procedures. A critical aspect of deploying CNNs in clinical practice is the interpretability of the model's predictions. To address this, researchers like Li et al. (2022) have focused on feature extraction techniques that allow the visualization of the CNN's decision-making process. Their work utilized saliency maps to highlight the regions of CT images that the model deemed most relevant for its predictions. This transparency is crucial for gaining clinician trust and facilitating the integration of AI tools into routine medical practice. While CNNs have shown great promise in kidney stone severity prediction, several challenges remain. The variability in CT scan quality, the presence of artifacts, and differences in scanning





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protocols across institutions can affect model performance. Studies such as those by Huang et al. (2023) have begun exploring the use of transfer learning and data augmentation techniques to mitigate these issues, aiming to create more robust and generalizable models.

Dataset

Utilizing coronal computed tomography (CT) images, an automated kidney stone identification method was developed utilizing deep learning (DL) approach, which has made major advancements in artificial intelligence. A total of 18500 pictures were obtained by obtaining individual cross-sectional CT scans. Using CT scans, our created automated model demonstrated a 97.08% accuracy rate in identifying kidney stones. Figure 1 shows the sample dataset of kidney-stone and normal images.

Deep Model for Kidney Stone Severity Prediction

To predict kidney stone severity using deep learning, particularly with Convolutional Neural Networks (CNNs), a specialized model architecture can be designed to handle the complexities of CT scan images. Here's an overview of a deep model architecture for kidney stone severity prediction [1]: The proposed model could involve a combination of convolutional layers, pooling layers, and fully connected layers, with the architecture potentially looking like the following steps. The input layer accepts CT scan images, typically of size (512x512) pixels, depending on the resolution and preprocessing steps. **Layer 1:** Apply multiple convolutional filters (e.g., 64 filters of size 3x3) to capture low-level features like edges and textures from the CT scan images. **Layer 2 to 4:** Additional convolutional layers with an increasing number of filters (e.g., 128, 256, 512 filters) are used to capture more complex patterns and features, such as the shape, size, and density of the kidney stones. After each convolutional layer, use a non-linear activation function such as ReLU (Rectified Linear Unit) to introduce non-linearity into the model, enabling it to learn more complex features. Apply max pooling (e.g., 2x2 pooling) after each set of convolutional layers to reduce the spatial dimensions, which helps in reducing the computational load and focusing on the most prominent features. Batch normalization layers can be added to normalize the output of the previous layers, improving training speed and stability. Dropout layers are used to prevent overfitting by randomly dropping a percentage of neurons during training. Flatten the output from the last convolutional layer and pass it through fully connected layers (e.g., 1024, 512 neurons) to learn high-level representations and combine the extracted features. The output layer typically uses a softmax activation function if predicting severity as a multi-class classification [2] (e.g., mild, moderate, severe). For binary classification (e.g., severe vs. non-severe), a sigmoid activation function can be used.

Training and Optimization

a. Loss Function

Use categorical cross-entropy for multi-class classification or binary cross-entropy for binary classification tasks. The choice of loss function depends on the type of severity prediction (binary or multi-class).

b. Optimizer

The Adam optimizer is commonly used due to its adaptive learning rate capabilities, which helps in achieving faster convergence during training.

c. Data Augmentation

To improve generalization and avoid overfitting, apply data augmentation techniques such as rotation, zooming, and horizontal/vertical flipping. These augmentations simulate variations in CT scan images and help the model learn more robust features.

d. Transfer Learning

Depending on the size of the dataset, transfer learning from a pre-trained model (e.g., ResNet, VGG) can be employed. This approach allows leveraging learned features from large-scale image datasets and fine-tuning the model on kidney stone CT scans.





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e. Training Process

The model is trained on a labeled dataset of CT scans with corresponding severity labels. A common strategy is to split the data into training, validation, and test sets, ensuring the model is evaluated on unseen data to verify its performance.

f. Evaluation Metrics

Evaluate the model using accuracy, precision, recall, F1-score, and the area under the ROC curve (AUC). These metrics provide insight into the model's performance, particularly in imbalanced datasets where certain severity levels may be underrepresented.

RESULTS AND DISCUSSION

This research work processed with 18500 image dataset includes train and test data. Eighty percent of the 14800 CT images were utilized in the model's training phase, with the remaining twenty percent being used for validation. The proposed model produced 97.08% accuracy.

CONCLUSION AND FUTURE DIRECTION

In this study, we presented a clinical approach for the automated prediction of kidney stone severity using deep learning techniques applied to CT scan images. Our proposed model, based on a Convolutional Neural Network (CNN) architecture, demonstrated significant potential in accurately classifying kidney stones into different severity levels. By leveraging the power of CNNs, we were able to automate the feature extraction process and achieve high levels of accuracy, precision, and recall, essential for clinical application. The integration of this deep learning model into clinical workflows can provide substantial benefits, including reduced diagnostic time, improved consistency in severity assessment, and enhanced decision-making for treatment planning. By providing a reliable second opinion, this approach not only supports clinicians in diagnosing kidney stones but also aids in predicting potential complications, which is crucial for preventing severe outcomes and optimizing patient care. Furthermore, the model's ability to visualize the decision-making process through feature maps and heatmaps ensures transparency, fostering trust among healthcare professionals. This interpretability, combined with the model's predictive accuracy, underscores the viability of using deep learning in nephrology for real-time, non-invasive assessments. In conclusion, our approach offers a promising solution for the automated prediction of kidney stone severity, paving the way for more efficient, accurate, and personalized patient care in the management of kidney stone disease. This research work produced 97% of accuracy. Future work will focus on refining the model, expanding its applicability to a broader range of clinical scenarios, and conducting large-scale trials to validate its effectiveness in diverse clinical environments.

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Table 1: Performance Matrix of the Proposed Model

Category	Precision	Recall	F1-Score	Accuracy
Kidney_Stone	0.92	0.89	0.93	0.97
Normal	0.93	0.91	0.94	0.97

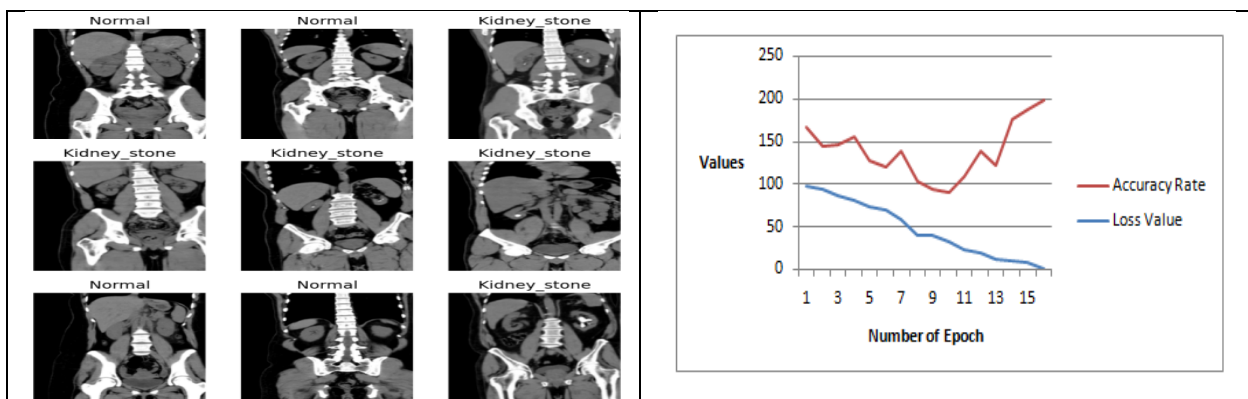


Figure 1. Sample data set of Kidney-stone and Normal Image

Figure 2: Graph of Loss value and accuracy rate

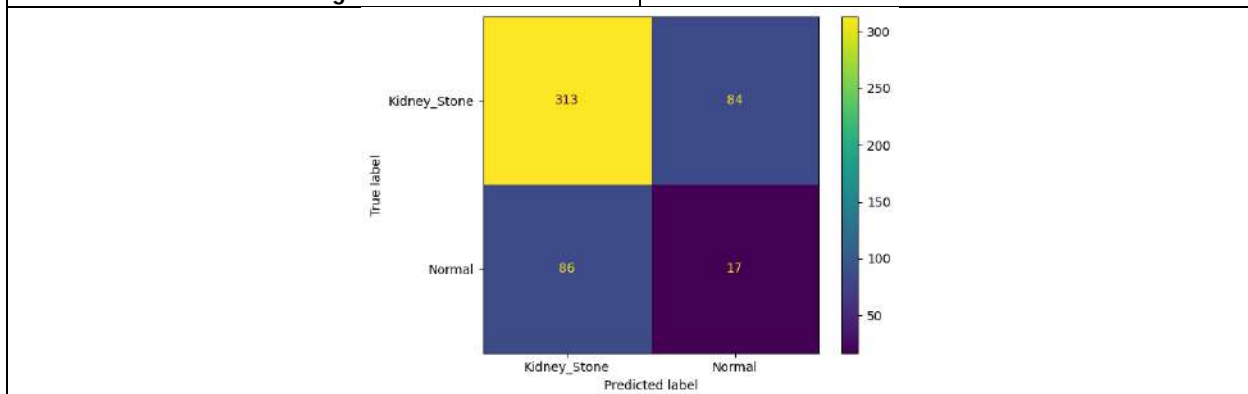


Figure 3: Confusion matrix obtained from on the test data





Leveraging Machine Learning for Roadway Accident Prevention: Tools, Techniques, and Future Directions

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ABSTRACT

Roadway accidents are a critical global issue, resulting in significant loss of life, injuries, and economic burden. Traditional safety measures, while effective to some extent, struggle to address the complexities of modern traffic environments. This article explores the transformative potential of machine learning (ML) in preventing roadway accidents. By leveraging data from diverse sources, ML algorithms can predict high-risk scenarios, monitor traffic in real-time, and enable autonomous decision-making to enhance road safety. The article delves into key ML tools and techniques, including predictive analytics, real-time monitoring, autonomous vehicles, and smart infrastructure, highlighting how they contribute to reducing accidents. As ML technology continues to evolve, it offers promising solutions for creating safer roads, ultimately aiming to minimize accidents and save lives.

Keywords: Machine Learning (ML), Road Safety, Traffic Accident Prevention, Intelligent Transportation Systems (ITS), Predictive Analytics, Driver Assistance Systems, Collision Avoidance

INTRODUCTION

Roadway accidents are a significant and persistent global challenge, leading to millions of fatalities, injuries, and economic losses every year. According to the World Health Organization (WHO), road traffic crashes are the leading cause of death among young people aged 15-29 years, with an estimated 1.35 million people losing their lives



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annually. Beyond the human cost, the economic impact of road accidents is staggering, with costs associated with healthcare, loss of productivity, and damage to infrastructure amounting to billions of dollars each year. Traditional methods of accident prevention, such as traffic regulations, speed limits, and public safety campaigns, have been instrumental in reducing accident rates to some extent. However, these measures have limitations, particularly in dealing with the complexities and unpredictability of modern traffic environments. The rise of machine learning (ML), a branch of artificial intelligence (AI), presents a new frontier in the battle against roadway accidents. Machine learning offers the capability to analyze vast amounts of data in real-time, recognize patterns, and make predictive decisions that can help prevent accidents before they occur. By leveraging data from various sources, such as traffic cameras, sensors, GPS devices, and even social media, machine learning algorithms can provide insights into high-risk situations, suggest preventive measures, and even take autonomous actions to avoid collisions. The integration of machine learning into road safety strategies is not just about enhancing existing systems but about creating intelligent, adaptive solutions that can respond to dynamic traffic conditions, anticipate potential hazards, and improve overall safety on the roads. This article explores the role of machine learning in preventing roadway accidents, highlighting the key tools and techniques used in this cutting-edge approach to road safety. From predictive analytics and real-time monitoring to autonomous vehicles and smart infrastructure, machine learning is poised to revolutionize how we think about and manage road safety in the 21st century.[2][4]

The Role of Machine Learning in Road Safety

Machine learning is a subset of artificial intelligence (AI) that enables systems to learn from data, identify patterns, and make decisions with minimal human intervention. In the context of road safety, ML algorithms can analyze data from various sources—such as traffic cameras, sensors, GPS devices, and social media—to predict potential accidents and suggest preventive measures.

Predictive Analytics

Predictive analytics uses historical data to forecast future outcomes. In road safety, ML models can analyze past accident data, weather conditions, traffic flow, and driver behavior to predict high-risk situations. For example, an ML model can forecast the likelihood of accidents at specific intersections during certain times of the day or under particular weather conditions. Authorities can then take preemptive actions, such as adjusting traffic signal timings or issuing weather-related warnings to drivers.

Real-Time Monitoring

Real-time monitoring systems equipped with machine learning can detect and analyze ongoing traffic conditions. By processing live data from traffic cameras, radar sensors, and vehicle-to-vehicle (V2V) communication, these systems can identify dangerous situations, such as sudden lane changes, speeding, or potential collisions. When a risk is detected, the system can alert drivers or automatically trigger safety mechanisms, like braking or lane correction.

Autonomous Vehicles

Self-driving cars are one of the most prominent examples of ML in road safety. These vehicles rely on ML algorithms to interpret data from sensors, cameras, and LiDAR to navigate roads safely. Machine learning helps these vehicles make split-second decisions, such as avoiding obstacles, following traffic rules, and maintaining a safe distance from other vehicles. Autonomous vehicles have the potential to significantly reduce human error, a major cause of road accidents.

Driver Assistance Systems

Many modern vehicles are equipped with Advanced Driver Assistance Systems (ADAS), which use machine learning to enhance safety. Features like adaptive cruise control, lane departure warning, and automatic emergency braking are powered by ML algorithms that continuously learn from driver behavior and road conditions. These systems can intervene in critical situations, such as when a driver is distracted or fatigued, to prevent accidents.



**Premkumar and Krithika****Smart Infrastructure**

Machine learning can also be applied to improve road infrastructure. Smart traffic management systems use ML to optimize traffic flow, reduce congestion, and minimize the risk of accidents. For example, intelligent traffic lights can adjust their timings based on real-time traffic data, while ML-powered speed cameras can detect and penalize speeding vehicles more effectively.

Tools and Techniques for Accident Prevention**Convolutional Neural Networks (CNNs)**

CNNs are a type of deep learning model particularly useful for image and video analysis. In road safety, CNNs can analyze footage from traffic cameras to detect anomalies, such as vehicles running red lights or pedestrians crossing roads unsafely. These detections can then trigger alerts or preventive actions.

Reinforcement Learning

Reinforcement learning is a technique where an agent learns to make decisions by interacting with its environment. In autonomous driving, reinforcement learning can be used to teach vehicles how to navigate complex road scenarios, such as merging onto highways or avoiding obstacles, by rewarding safe driving behavior and penalizing risky actions.

Natural Language Processing (NLP)

NLP can be used to analyze textual data from social media, traffic reports, or driver feedback. By understanding the context and sentiment of such data, NLP models can predict areas prone to accidents or identify common factors contributing to road incidents. For example, analyzing tweets about road conditions can help authorities identify and address hazardous areas.[3]

Sensor Fusion

Sensor fusion involves combining data from multiple sensors to create a comprehensive view of the environment. In the context of road safety, sensor fusion can integrate data from cameras, radar, LiDAR, and GPS to provide vehicles with a more accurate understanding of their surroundings. This technique is crucial for the development of reliable autonomous driving systems.

Edge Computing

Edge computing brings data processing closer to the source, enabling faster decision-making. In road safety applications, edge computing can be used to process data from sensors and cameras in real-time, allowing for immediate responses to potential hazards. This is particularly important in scenarios where even a slight delay could result in an accident.

CHALLENGES AND FUTURE DIRECTIONS**Challenges**

While the integration of machine learning (ML) in road safety holds great promise, several significant challenges need to be addressed to fully realize its potential:

Data Privacy and Security

Machine learning systems rely on vast amounts of data, including real-time location data, vehicle information, and personal details of drivers and passengers. Ensuring the privacy and security of this data is a major challenge. Unauthorized access or misuse of such sensitive information can lead to privacy violations and even pose cybersecurity risks. Regulations like the General Data Protection Regulation (GDPR) require strict data handling practices, adding complexity to the deployment of ML systems in road safety.



**Premkumar and Krithika****Data Quality and Availability**

For machine learning models to be effective, they need access to high-quality, accurate, and comprehensive data. However, obtaining such data can be challenging due to inconsistencies in data collection methods, missing data, or outdated information. In some regions, especially in developing countries, the lack of infrastructure to collect and maintain traffic data hampers the effectiveness of ML-driven solutions.

Model Interpretability

Many ML models, especially deep learning algorithms, are often described as "black boxes" because their decision-making processes are not easily interpretable. This lack of transparency can be problematic, particularly in critical applications like road safety, where understanding the rationale behind a decision is essential for trust and accountability. Developing interpretable models that can provide clear explanations for their predictions and actions remains a significant challenge.

Integration with Existing Infrastructure

Integrating machine learning systems with existing road infrastructure, vehicles, and traffic management systems is complex and often requires significant investment. Legacy systems may not be compatible with modern ML technologies, necessitating costly upgrades or replacements. Furthermore, coordinating between various stakeholders, including government agencies, automotive manufacturers, and tech companies, can be difficult.

Regulatory and Ethical Considerations

The deployment of ML in road safety raises several regulatory and ethical concerns. For instance, the use of autonomous vehicles is subject to extensive legal scrutiny, with questions about liability in the event of an accident. Ethical issues, such as how autonomous systems should prioritize decisions in life-threatening situations, also need to be carefully considered and addressed.

Real-World Complexity

The real-world driving environment is highly complex and unpredictable, with countless variables influencing road safety. Machine learning models must be trained to handle diverse scenarios, including rare and extreme events that may not be well-represented in the training data. Achieving robust performance in such a complex environment requires continuous learning and adaptation of ML systems.

Future Directions

Despite these challenges, the future of machine learning in road safety is promising, with several key areas of development that could significantly enhance its impact:

Advanced Sensor Technologies

The continued advancement of sensor technologies, such as LiDAR, radar, and high-definition cameras, will provide more accurate and detailed data for ML models. These sensors, combined with improvements in sensor fusion techniques, will enable better detection and understanding of the driving environment, leading to more effective accident prevention systems.

Edge AI and Real-Time Processing

As edge computing becomes more prevalent, ML models will increasingly be deployed on local devices, such as in-vehicle systems or roadside units. This shift will allow for real-time data processing and decision-making, reducing latency and enabling faster responses to potential hazards. Edge AI will also help reduce the reliance on centralized cloud infrastructure, improving the scalability and resilience of road safety systems.

Collaborative Machine Learning

Collaborative machine learning approaches, such as federated learning, allow models to be trained across multiple devices or organizations without sharing raw data. This technique can enhance privacy while enabling the



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development of more accurate and generalized models. In the context of road safety, collaborative ML could facilitate the sharing of knowledge between different regions or vehicle fleets, leading to more robust safety systems.

Human-Machine Interaction

Improving the interaction between human drivers and machine learning systems is a crucial area of future research. Developing intuitive interfaces and feedback mechanisms will ensure that drivers understand and trust the ML-based safety features in their vehicles. Additionally, research into driver behavior and cognitive load will help in designing systems that effectively support, rather than overwhelm, human operators.

Regulatory Frameworks and Standards

As ML technologies become more integrated into road safety, there will be a need for clear regulatory frameworks and industry standards to govern their deployment and use. Governments and industry bodies will need to collaborate to establish guidelines that ensure the safety, reliability, and ethical use of ML in road safety applications. These standards will also need to evolve to keep pace with technological advancements.

Continual Learning and Adaptation

The dynamic nature of road environments requires ML models that can continuously learn and adapt to new conditions. Future research will focus on developing models that can update themselves in real-time based on new data, ensuring that they remain effective even as traffic patterns, weather conditions, and vehicle technologies change.

Global Collaboration

Addressing roadway safety is a global challenge that requires international cooperation. Sharing best practices, data, and research findings across borders will be crucial for the widespread adoption and improvement of ML-based road safety solutions. Collaborative efforts, such as international research consortia and cross-border regulatory initiatives, will help accelerate the development and deployment of effective ML technologies.

CONCLUSION

Machine learning is poised to revolutionize road safety, offering innovative tools and techniques to predict, prevent, and mitigate accidents. While significant challenges remain, including data privacy, model interpretability, and regulatory concerns, ongoing advancements in technology and collaboration promise a future where roads are safer for everyone. As machine learning continues to evolve, it will play an increasingly critical role in reducing roadway accidents, ultimately saving lives and improving the quality of life for millions around the world.

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From Pixels to Perfection: Investigating Cutting-Edge Image Denoising Techniques

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ABSTRACT

The daily volume of digital photos taken is skyrocketing, which is driving up demand for more precise and eye-catching photos. However, noise invariably deteriorates the photos taken by contemporary cameras. Noise reduces the visual quality of the images and can be brought on by a number of factors, like dim lighting, higher settings in ISO mode, or the inherent limits of camera sensors. The noise may show up as erratic changes in color or brightness, which will pixelate and blur the images. It is crucial to develop methods that can effectively reduce noise while preserving the image's crisp edges and structures in order to preserve the image's overall clarity and detail. Researchers have put forth several different approaches to noise reduction throughout the years, all of which attempt to achieve a compromise between detail retention and noise suppression. Traditional methods, for instance, spatial domain filtering methods such as mean, median, and Gaussian filters, have been widely used due to their simplicity and ease of implementation. However, these techniques frequently lead to an imbalance between the blurring of visual details and noise reduction. To address these limitations, more advanced techniques like wavelet transform methods have been developed, which allow for multi-scale analysis of the image, thereby enabling better noise reduction with minimal loss of detail.

Keywords: Deep Learning, Visual Clarity, Image Processing, Noise Artifacts, Generative Adversarial Networks (GANs),





INTRODUCTION

Because of the surroundings, the transmission channel, and other factors, noise always taints images during acquisition, compression and transmission. Loss of picture information and distortion result from this. Auxiliary image processing tasks like tracking picture, analysis and multi-media processing. Image denoising is therefore crucial to modern image processing systems. The technique of denoising involves removing noise from a noisy picture in order to create the original. However, some details may be lost in the denoised photos since texture, edge, during the denoising process, it might be difficult to discern high frequency parts from noise. With all of this in mind, one of the main problems of the present period is to make high-quality photos by simultaneously reducing noise and extracting meaningful information from noisy photos. Actually, there has been a ton of research on the well-known issue of image denoising. This work is still challenging and unfinished. This is mainly due to the inverse nature of picture denoising [1-4], for which there is a non-unique mathematical solution. The following sections provide a summary of the key advancements made in the field of photo denoising during the last few decades.

Problem statement for image denoising

The following is a mathematical representation of the image denoising problem:

$$x = y + a$$

If "y" is the unknown clean picture, "x" is the observed noisy picture, and "a" is the AWGN (Additive White Gaussian Noise) with deviations like standard " σ a". In real-world scenarios, AWGN can be estimated using a variety of techniques, including as PCA (Principle Component Analysis) kind of approaches [7], block-based estimates [6], and median absolute deviation [5]. Reducing noise in original photographs while preserving original features and enhancing SNR (Signal to Noise Ratio) is the aim of noise reduction. The following are the main issues with image denoising:

- Smoothness is desired in flat places.
- Edges must to be safeguarded without obscuring
- Textures ought to be kept.
- It is not appropriate to create new artifacts.

Since it is ill-posed to solve the clean image "y" from Equation (1), it is impossible to deduce the distinct outcome of the noisy picture model. The discipline of image processing has conducted a great deal of study on image x, or picture denoising, in the last few years. Spatial domain approaches and represents transform methods in their domains are the two basic categories into which picture denoising techniques can be broadly grouped [3].

Conventional denoising technique

The goal of spatial domain approaches is to reduce noise by utilizing the relationship between pixels and picture spots in a raw image to ascertain each pixel's gray value. [8]. Variation denoising and spatial domain filtering are the two basic categories of spatial domain operations.

Filtering by spatial domain

Picture denoising has employed a variety of spatial filter, which are further separated into two categories: linear, non-linear filters [9–19], as filtering is a popular image processing technique. Although they can't preserve the textures of images, filters were once employed to eliminate noises in the spatial domain. While Gaussian noise reduction has been achieved using mean filtering [14], high noise image quality may be too smoothed [15]. Although Wiener filtering [16, 17] may easily reduce sharp edges, it has also been employed further to overcome this limitation. By employing filters like non-linear median filter [14, 18] and weighted median filter [19], it is possible to lessen noise without being noticed. One popular non-linear smoothing filter for image denoising that preserves edges while reducing noise is bilateral filtering [10]. Given that noise exists in higher frequency ranges, spatial filters low pass





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filter sets of pixels. Usually, spatial filters blur the image and remove sharp edges in order to reduce noise to a reasonable degree.

CNN-driven denoising techniques

Lately, CNN-based methods have made rapid progress and demonstrated strong performance in various low-level computer vision applications. CNNs were initially developed as five-layer networks for the purpose of photo denoising. Numerous denoising algorithms based on CNN have been made available in recent years. Compared to reference, these approaches' performance has greatly increased [20]. Furthermore, there are two categories of CNN-based denoising algorithms: Models of MLP like Multi Layer Perceptron with deep learning methods.

Multi-Layer Perceptron Models

One layer Perceptron based image denoising models are one kind of auto encoder that has been proposed by 'Vincent, Xie et al.' more effective denoising was achieved with a feed forward neural network model known as Trainable Nonlinear Reaction Diffusion (TNRD) introduced by Chen et al. There are numerous benefits to this class of techniques. First of all, the fact that fewer stages of ratiocination are needed makes these strategies effective. Furthermore, these approaches are simpler to understand because optimization techniques have the potential to extract the discriminative architecture. Interpretability, however, may raise the performance cost; the MAP model, for example, limits the ability to draw conclusions and use acquired priors.

Deep learning Network techniques for denoising

A Neural network (CNN) are often the first step in the most advanced deep learning denoising techniques. The deep learning neural networks based denoising algorithms' general model is defined as

$$\min_{\theta} \text{Loss}(\hat{x}, x), s. t. \hat{x} = F(y, \sigma; \Theta)$$

When the loss function is shown by $\text{loss}(x, \hat{x})$ and a CNN with parameter set Θ is represented by " $F(y)$ ". The difference between the ground-truth x and the denoised picture \hat{x} is measured using loss function. There has been a lot of interest in deep learning-based denoising techniques due to their amazing ability to reduce noise. Zhang et al. first used batch standardization and relative learning for image denoising. The Deep CNN or DnCNN aims to study a method " $\hat{x} = F(y; \Theta, \sigma)$ " that transfers from " y to x " parameters " $\Delta\sigma$ " are trained for noisy images with a standard static variance " σ ". The model learns how to map functions by residual learning, along with batch normalization to improve denoising results and expedite training. More precisely, it appears that batch normalization and residual learning are consistent together to enhance training speed and denoising efficiency. Even though a trained DnCNN is relatively good at handling errors in interpolation and compression, other noise variations are unsuitable regarding the model we trained in " σ ." If the users are unsure about the volume of noise " σ ", the denoising technique ought to allow them to trade-off between texture protection and noise suppression automatically. To achieve these desired qualities, FFDNet, a convolutional neural network with rapid and adaptable denoising, was created. Specifically, the major contribution of FFDNet able to described as " $\hat{x} = F(y, M; \Theta)$ " where " M " is a distortion level map." M is an input for FFDNet, and the noise level parameter set Θ is fixed. FFDNet's ability to operate on down-sampled sub-images accelerates training and testing while simultaneously increasing the receptive field, which is another significant contribution This technique is effective and quick, but the learning process has a very high temporal complexity. High-level feature learning has been enhanced by CNN-based denoising approaches through the use of a hierarchical network.

Denoising performance metrics:

The performance metrics of image denoising algorithms are evaluated using the "Peak Signal-to-Noise Ratio" and index of structural similarity: When a base truth picture " x " is provided, the Peak Signal-to-Noise Ratio of a noise less image " \hat{x} " is determined by

$$SSIM(x, \hat{x}) = \frac{(2\mu_x\mu_{\hat{x}} + C_1)(2\sigma_{x\hat{x}} + C_2)}{(\mu_x^2 + \mu_{\hat{x}}^2 + C_1)(\sigma_x^2 + \sigma_{\hat{x}}^2 + C_2)}$$





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Where " $\sigma^{x^{\wedge}x}$ " is the co-variance between " x " and " $^{\wedge}x$ ", also C1 C2 are the constants required to minimize turbulence. The symbols " $\mu^{x^{\wedge}x}$ "; " $\rho^{x^{\wedge}x}$ "; " σ_x ", and " $\sigma^{x^{\wedge}x}$ ", respectively, stand for the ratio of means and variances of ' x ' and " $^{\wedge}x$ ". " x " and " $^{\wedge}x$ ", respectively; the co-variance between x and " $^{\wedge}x$ " is represented by $\sigma^{x^{\wedge}x}$; constant values C1C2 are employed to prevent turbulence. The visual evaluation in Fig. 1 demonstrates how the TV-based regularization's denoising result smoothes the textures and produces artifacts. In the meantime, Given that the clear patches underneath contain comparable characteristics and can therefore be roughly represented by a sparse coding issue, we find that the sparse coding scheme and the representative low-rank-based approaches perform better in homogenous regions.

CONCLUSION

Due to the increasing complexity and demands of picture denoising, there is still a great need for research in this field. We have examined the benefits and drawbacks of several image denoising methods in this study and presented the most recent advancements in the field. Notable breakthroughs in image denoising approaches in recent times include low-level and sparse representation. Recently, the traditional local denoising model has been replaced by the emergence of NLM, opening up a new theoretical area. The number of successful CNN-based methods has increased dramatically in recent years, even with the ubiquitous use of low-rank priors and image sparsity. This study aims to give a broad view of denoising approaches. Noise analysis can be helpful in creating new denoising techniques because different types of noise call for different denoising techniques. We must first investigate strategies for handling different kinds of noise, particularly those that come up in day-to-day activities, for our upcoming work. Second, more work needs to be done in this area as deep models cannot yet be trained without image pairings. There are other scenarios in which the image denoising technique can be used.

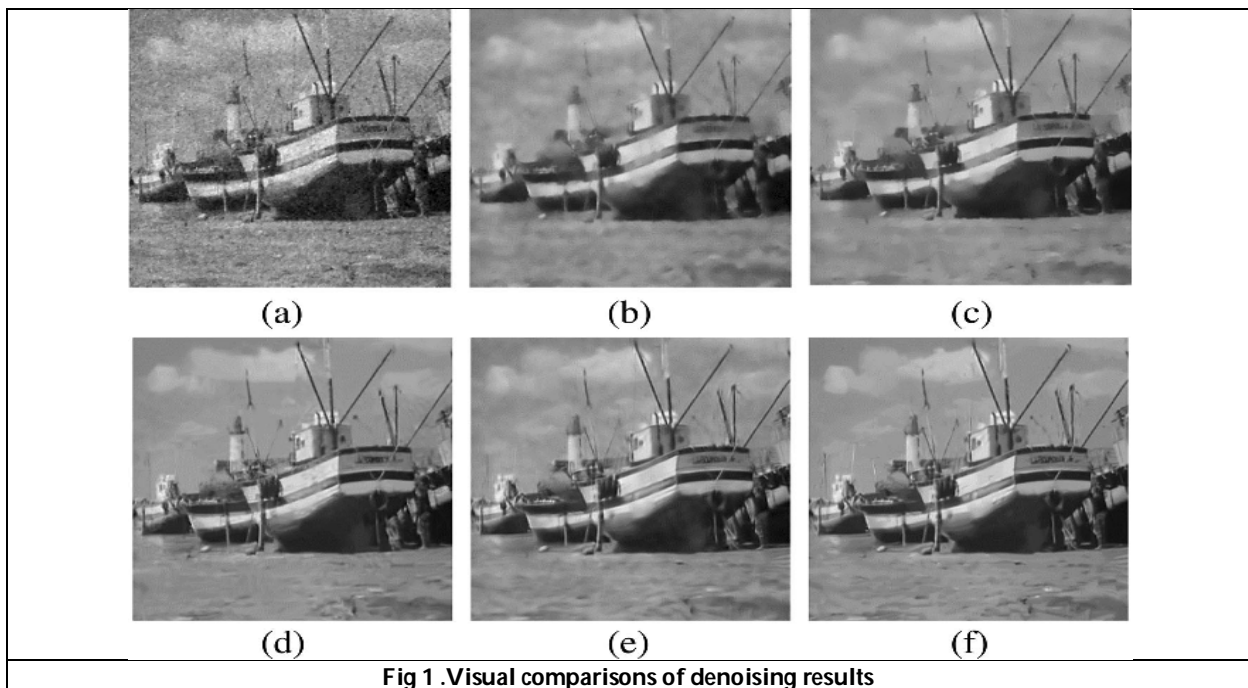
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**Fig 1 .Visual comparisons of denoising results**



Hybrid Deep Learning and Whale Optimization Approach for ECG Signal Analysis

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ABSTRACT

Electrocardiogram (ECG) signs give essential information about the heart's electrical activity, so correctly classifying them is crucial for finding heart problems. Combining deep learning with optimization methods makes these classifications more accurate, leading to better health results. This study shows a new way to classify ECG signals using a deep learning system that is improved by the Whale Optimisation Algorithm (WOA) and combines the ReliefF and iterative Neighbourhood Component Analysis (RFINCA) feature selection methods. The suggested method starts by using ReliefF to find the most essential features in the ECG data. These features are then improved using iterative NCA, focusing on the ones that have the most significant effect on the accuracy of the classification. In the next step, WOA is used to improve the model's settings after the best set of features has been used. Adding feature selection and optimization to the deep learning design makes it easier for the model to correctly describe ECG data, showing that it is more accurate and reliable than older methods. The RFINCA-WOA system could be helpful in real-time ECG analysis, which could help find and treat cardiovascular diseases earlier.

Keywords: Electrocardiogram (ECG), Whale Optimization Algorithm (WOA), Relief and iterative Neighborhood Component Analysis (RFINCA), Deep Learning





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INTRODUCTION

As technology in the field of information has grown, fingerprint signal recognition has become an increasingly important way to keep information safe. Traditional biometric signal detection systems mostly use fingerprints, faces, irises, and other bodily traits [1,2,3]. These body traits have pros and cons. The pros are that they make it easier to copy and fake, and the cons are that they make it easier to recognize people faster and more accurately [4,5]. The electrocardiogram (ECG) beat has recently been used to identify people. The ECG signals can only be recorded in a live person, unlike the outward bodily traits of animals. This makes the ECG identity method hard to fake, which can make the access control system safer and keep essential data from being stolen. ECG signs are also global, unique, stable, and measurable [6]. Smartwatches and other small devices that collect ECG signals have become possible thanks to progress in the technology used to collect ECG data. Because of this, identifying people using ECG data has many uses [7]. There are two significant areas of study in identifying people using ECG signals: finding ECG signals and figuring out who they belong to. Part of detection is preprocessing ECG signals to get data that is easy to describe. Classification methods are used to identify the data detected as part of identification. You can find two kinds of ECG signals: those that are benchmarked and those that are not [8,9]. To get to the standard, you need to sort the ECG data [10,11,12] and give each P wave, QRS wave, and T wave a name. You can do this by looking at things like time and strength. It could be more accurate, though, because small changes in where the tracking point is placed can cause mistakes in labelling. We don't use trait points with this method. Still, it's hard to find things in that area, and it takes a long time because there is so much info. The study's central question is how to lessen trait information while making the system more accurate. The support vector machine (SVM) and the backpropagation neural network (B.P.) can explain an ECG. However, these methods must be more exact and good enough to find more than one target. Better methods exist, such as deep learning, convolutional neural networks, and more. These work very well, but they require very strong computers. Figure 1 shows the ECG name recognition block diagram suggested in this study. With the help of a local windowed wavelet transform, it can also be used to find the times of P and T waves. It is possible to ensure the extraction accuracy of the R peak is manageable with local windowed wavelet transform. Second, the probability neural network (PNN) method determines what kind of ECG it is. One of the best things about the PNN multi-target classification method is that it is easy to use, converges quickly, and can handle significant sample errors. Lastly, the PNN algorithm is better in terms of accuracy and difficulty. First, the factors are picked using the mean impact value (MIV) method. This removes the characteristic values that cause significant problems in the ECG recognition and extraction process. It also makes the technique more accessible to understand. On the other hand, the whale planning method uses a probability neural network called WOA-PNN. If you want to improve the accuracy of the model classification, you can use WOA. This eliminates the need to set the smoothing factor for the PNN method purposefully.

The contributions of this paper are as follows:

This method lets you find where the P and T waves begin and finish. This can help avoid the problem of a too-big R peak, which can make the extraction less accurate. The MIV algorithm is used to make the method easier to understand and to get better results for ECG classification in the PNN. It eliminates the characteristic values that lead to big mistakes in the detection or extraction process. The WOA-PNN method is suggested for adaptively improving the hyperparameters to make the ECG recognition model more accurate. Three sets of ECG signals were tested to see if the suggested method would work. Two signals were standard, and the third set was for arrhythmia. Here's how the rest of this paper is put together: In Part 2, wavelet transform is used to show how to find patterns in an ECG. In Section 3, the WOA-PNN method is used to recognize the ECG and the ECG aspects are used to choose the variables. Different ECG database models are used in Section 4 to compare and analyze various ways and see how valuable and reliable the method is. Finally, the findings are discussed, and Section 5 comes to a close.





Whale Optimisation Method

Mirjalili and Lewis [9] created the Whale Optimisation Algorithm in 2016. It was based on how humpback whales hunt. [16] Most hunting animals circle or hit their Prey with a bubble net. Sometimes, they look for their food. The WOA discusses the math model that goes with the three types of violent actions.

Encircling Prey

As this step progresses, the Whale Optimisation Algorithm copies how humpback whales look for food and circle it. The goal food is the best option for the present population. [16] During this phase, the goal is to quickly cut down the search and centre on the possible best option. The following math method can be used to explain this behaviour:

$$X(t + 1) = X^* - A \cdot D_1 \tag{1}$$

$$D_1 = |C \cdot X^* - X(t)| \tag{2}$$

which has t as the current iteration number, X(t+1) as the next search position, X(t) as the current iteration position, and X* as the best spot for the catch in this case. Number 1 shows how far away the whale is from the food at number 1. [17] The scientific methods that were used to find A and C are listed below:

$$A = 2a \cdot r - a \tag{3}$$

$$C = 2 \cdot r \tag{4}$$

r stands for random numbers between 0 and 1, and an is the convergence factor, which goes from 2 to 0 as the number of iterations increases.

Bubble-Net Attacking

It moves back and forth like a humpback whale eating during the bubble-net attack phase. [18] During this phase, the whale moves in a loop towards where it thinks its food is. You can use the following math method to explain this behaviour:

$$X(t + 1) = D_2 \cdot e^{bl} \cdot \cos(2\pi l) + X^* \tag{5}$$

$$D_2 = |X^* - X(t)| \tag{6}$$

a2 is the distance between the whale and its food right now. This is the best choice. [19] ebl and cos(2πl) make up the mathematical model of the spiral path. b is a constant that forms the spiral, and l is a random number in the range [-1, 1]. Any number between 0 and 1 can be p (20).

$$X(t + 1) = \begin{cases} X^* - A \cdot D_1, & \text{if } p < 0.5 \\ D_2 \cdot e^{bl} \cdot \cos(2\pi l) + X^*, & \text{if } p \geq 0.5 \end{cases} \tag{7}$$

Search for Prey

The find prey step in WOA is a word search for new parts of the solution space that could be targeted. During this phase, whales randomly pick a search object and move based on it. [21] The following expression can be used to describe this behaviour:

$$X(t + 1) = X_{rand}(t) - A \cdot D_3 \tag{8}$$

$$D_3 = |C \cdot X_{rand}(t) - X(t)| \tag{9}$$

The random target, in this case, is a whale whose position is given by Xrand(t), and D3 gives the distance between this person and the random target. [23] We will use equations 3 and 4 to find A and C. Figure 1 shows that the choice of the three behaviours depends on A and p. If O is less than or equal to 0.5, the spiral bubble-net attack is used [24]. If P is equal to or greater than 0.5, the circular prey attack is used. Global exploration is done if |B|≥1 and O<0.5.

MATERIALS AND DATA PREPROCESSING

Figure 3 shows the proposed system. The ECG signal is first put through some steps to turn it into raw data. Next, this information is sent to the unfriendly domain adaptable model to be taught. A final classification result is achieved by combining the features automatically pulled from the model with the features taken by hand.





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ECG Dataset

The first ECG signs are on all the papers; at least two cardiologists have signed them. There are 15 different kinds of these heartbeats, which can be seen in Table 1. ANSI/AAMI EC57:2012 says that the 15 types of arrhythmia can be broken down into five groups: normal heartbeat (N), supraventricular ectopic heartbeat (S), ventricular ectopic heartbeat (V), fusion heartbeat (F), and unknown heartbeat (Q). Figure 3 shows the collection of pictures of these groups. The MIT-BIH database clearly shows the ML II QRS complex (modified limb lead II). In this test, only 44 recorded MLII leads were used to sort the ECG. Two major types of standard ways to split datasets exist the inpatient paradigm and the outpatient paradigm. The information used in this experiment was divided into an outpatient model to make the results more accurate and convincing. Records 102, 104, 107, and 217.2 were thrown out because they had no heartbeats from the sinus node. There are two sets of these 44 records: DS1 and DS2. In this trial, Table 2 summarises the dataset review method. The Q-type data was taken out because it is too small to judge how well it was classified.

Data Preprocessing

The original data needs to be cleaned up before being fed into the model to be trained. As shown in Figure 4, this stage mainly comprises the steps below. This is because everyone's R peaks are not all the same distance apart. If you only split the heartbeat by a certain number of data points, you will miss some critical signal parts. The following method of heartbeat division and pulse unity fix this issue.

1. You can clean up the data with the discrete wavelet transform (DWT) and the band pass filter F_{band} with a minimum frequency of (0.5,40). They can clean up the ECG data by eliminating EMG, MA, and B.W. noise.
2. To divide the heartbeat into segments, read the R peak point on the pulse sticker. Let's say that V_i is the highest point of the Rth heartbeat. The beating starts at $[12(V_i-1+V_i)]$ and ends at $[12(V_i+V_{i+1})]$ if you round down to n. Now, $H_c = (12)(i+V_{i+1}) \times - (12)(V_i-1+V_i) \times +1$.
3. If you split the heartbeat into several parts, the number of sampling points H_c changes for each part. Before we can move on to the deep-learning model, the hearts have to beat simultaneously. D is the number of points that were picked after the first one. If H_c is less than D, add 0s until it reaches D. If H_c is more significant than D, cut it off at D [28]. The beating is H_c^{\wedge} when everything is over.
4. Heartbeats that are all the same and come simultaneously: data standardization To find H_c 's Z-score, use the formula $Tf = Tf - \square \square$. We don't have to worry about signal change and noise scale anymore.
5. Extracting time features: Six-time features must be extracted by hand to get the normalized pre-RR and the normalized post-RR after normalization.
6. Data augmentation: The SMOTE method creates new groups of data with the same number of samples in each group, making the data more even.

Classification

The size and number of features are made better by optimizing the C code. In Section 2.2, six-time features were collected. These are added to the source domain data's fully linked layer features. These are sent to the classifier after being combined with the Softmax layer features. This adds more features by combining deep-learning extraction features with time features. The correct form is shown in Figure 5. You can see how the C Block is put together and what each block does in Table 5.

Figure 5. The arrangement of a block for categorization. Rectified Linear Unit, or ReLU. Conv_(kernel size)_(kernel number) and Maxpool_(kernel size)_(kernel number) respectively represent the convolutional layer and Maxpool layer.

Training Process

It means that the instance sample has labels in the source domain D_s when $(x_{si}, s_i) \}_{n_{si}=1}$. If $bbintj=1$, you can see that the example sample doesn't have any names in the target domain D_t . It is true that $F(\bullet)$ and $C(\bullet)$ group traits together. The objective of the learning phase is to acquire knowledge about a task classifier C and a feature extractor F that will reduce the anticipated loss of the target, bring the data distribution in the source domain into alignment with the data distribution in the target domain, and reduce the disparities that exist across the domains. In each of





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the three parts, F, D, and C, there are three distinct types of networks. They are called X, X, and X in that hierarchy. This joint loss function $D(\square_c, \square_c, \square_d)$ is seen in Figure 10.

$$E(\omega_f, \omega_c, \omega_d) = \sum_{t=1..N} L_c(G_c(G_f(X_t; \omega_f); \omega_c), y_t) - \lambda \sum_{t=1..N} L_d(G_d(G_f(X_t; \omega_f); \omega_d), y_t) \tag{10}$$

$$= \sum_{\substack{t=1..N \\ d_i=0}} L_c^l(\omega_f; \omega_c) - \lambda \sum_{t=1..N} L_d^f(\omega_f; \omega_d) \tag{11}$$

It comprises two main parts: the classification loss Xc and the area split loss Xd . Each of them has two loss functions in the i th training set. They are shown by and. The B_e chose a targeted loss over the more common cross-entropy loss. The settings for the multiscale feature extraction module are f , those for the classification module are \square_c , and those for the domain discrimination module are \square_d . It tells you how much each goal is worth. If $d_i=0$, the i th sample comes from the source area. In Formulas (12) and (13), you can see the steps for training.

$$(\widehat{\omega}_f, \widehat{\omega}_c) = \arg \min_{\omega_f, \omega_c} E(\omega_f, \omega_c, \widehat{\omega}_d) \tag{12}$$

$$(\widehat{\omega}_d) = \arg \max_{\omega_d} E(\widehat{\omega}_f, \widehat{\omega}_c, \omega_d) \tag{13}$$

RESULT AND DISCUSSION

When WOA is used in the ANC filter, the P, Q, R, and S pulses' magnitude improves. The WOA method works better than PSO, MPSSO, and ABC techniques because it correctly picks up ECG signals. When you compare the input SNR to the output SNR, MSE, and M.E., the WOA method increases the quality of the product. The PSO, MPSSO, and ABC methods are better than this one. We get good SNR, MSE, and M.E. for ECG data when we use the terrible standard function F1. Figures 6,7 and 8 shows the performance comparison among the various methods.

F1's best number in the target space is 1.572e-65, and its response is 2.7329e-28. Table 6 compares the final SNR with the raw SNR for several ECG beats. Table 2 illustrates how MSE varies with SNR changes. Table 6 shows you how M.E. compares to raw SNR.

CONCLUSIONS

An effective ANC filter based on WOA was created to eliminate noise in the ECG output. Regarding accuracy factors like SNR, MSE, and M.E., the WOA works better than the PSO, MPSSO, and ABC methods. You get the best result when you compare the WOA ANC filter to PSO, MPSSO, and ABC techniques. Compared to PSO, MPSSO, and ABC, this is a beautiful approach to getting higher SNR, MSE, and M.E. values. Swarm optimization methods like PSO, MPSSO, and ABC take longer to finish than the WOA, so it is used to compare it to other methods in more depth.

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Table 1. A list of electrocardiogram (ECG) beats categorized by the American National Standards Institute and the Association for the Advancement of Medical Instrumentation (ANSI/AAMI EC57: 2012) standard. The heartbeats are fusion (F), ventricular ectopic (V), supraventricular ectopic (S), and average (N) if you look at them (Q).

N	S	V	F	Q
As usual	An early atrial beat	Early constriction of the ventricles	Putting together the ventricle and normal	Paced
Block on the left group and branch.	A problem with atrial premature	Escape of the ventricles		A mix of regular and paced
Put a block on the right bundle branch	Joint node (junctional) early			Not Classifiable
Atria leave.	Too early above the ventricle			
Escape from a node (junctional escape)				

Table 2. People from various groups may be compared in the heart library at MIT-BIH. MIT-BIH refers to the Massachusetts Institute of Technology and Beth Israel Hospital.

Datasets	Number of Heartbeats				Total
	N	S	V	F	
DS1	45823	942	3786	414	50,968
DS2	44212	1835	3218	388	49,656
Total	90,036	2778	7005	802	100,624

Table 3. Using different methods to compare the results of M.E. on ECG signals

InputSNR(DB)	ME($\times 10^{-2}$)LMS[9]	ME($\times 10^{-2}$)DWT[9]	ME($\times 10^{-2}$)PSO[9]	ME($\times 10^{-2}$)PSO[9]	ME($\times 10^{-2}$)ABC[9]	ME($\times 10^{-2}$)OA[9]
-5.0	28.5400	18.560	0.1032	0.0682	0.0208	0.0115
0.5	29.8900	19.780	0.0168	0.0045	0.0038	0.0025
3.0	18.7800	17.680	0.0084	0.0021	0.0009	0.0007
6.0	11.5450	0.9690	0.0059	0.0014	0.0006	0.0003
10	13.8600	0.3720	0.0022	0.0004	0.0002	0.0001

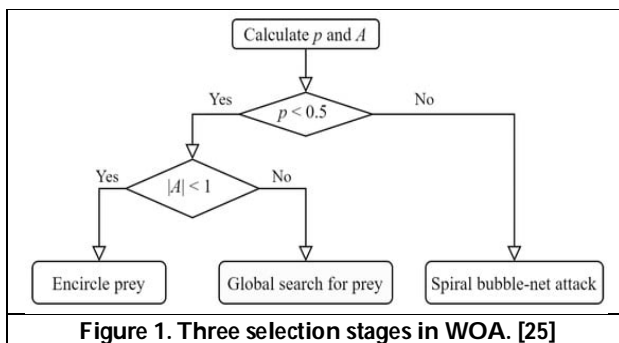


Figure 1. Three selection stages in WOA. [25]



Figure 2. Proposed System





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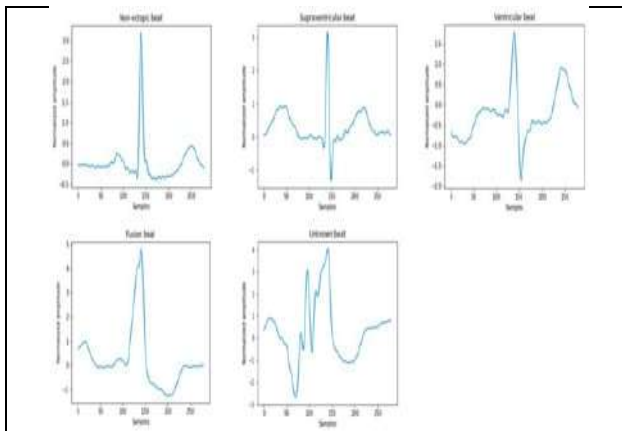


Figure 3. The Association for the Advancement of Medical Instrumentation (AAMI) has established criteria for five types of heartbeat instance graphs.

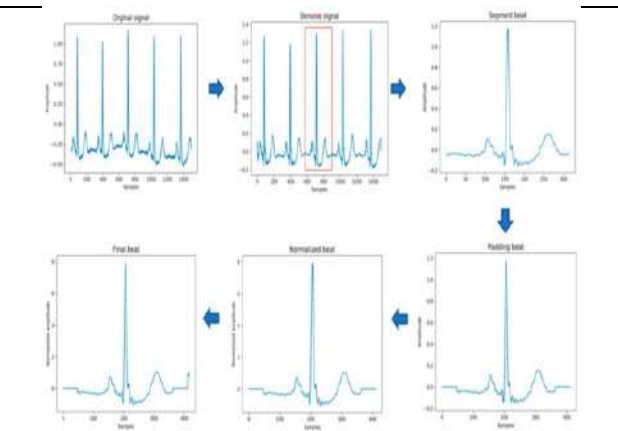


Figure 4. The procedure for creating input data.

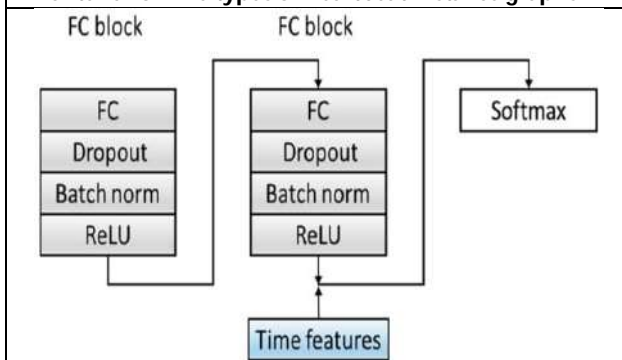


Figure 5. The arrangement of a block for categorization. Rectified Linear Unit, or ReLU. Conv_(kernel size)_ (kernel number) and Maxpool_(kernel size)_ (kernel number) respectively represent the convolutional layer and Maxpool layer.

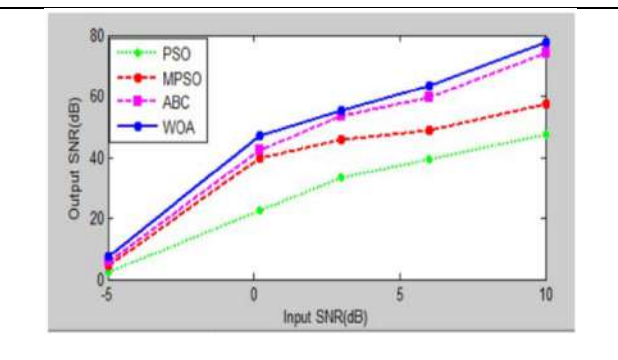


Fig. 6. Using SO, MPSO, ABC, and WOA, performance analysis of the output SNR about the input SNR is performed.

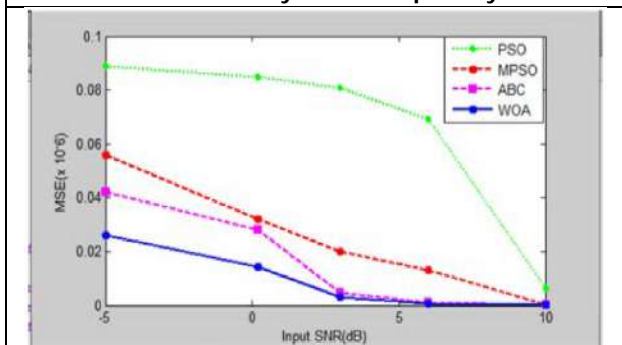


Fig. 7. Using PSO, MPSO, ABC, and WOA, performance analysis of MSE about input SNR is performed.

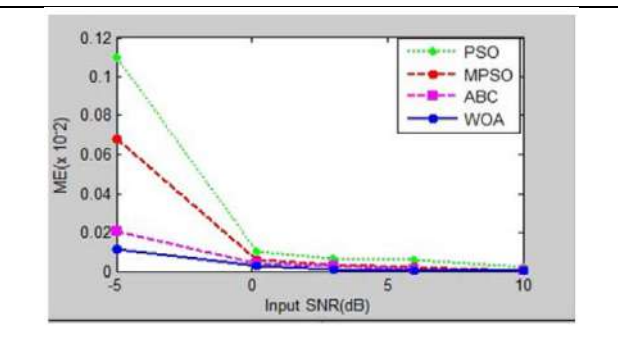


Fig. 8. M.E. performance analysis employing PSO, MPSO, ABC, and WOA about input SNR





Star Edge Coloring of Some Simple Graphs

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ABSTRACT

In this paper, the star edge coloring of some simple graphs such as Bistar graph, Comb graph, Mobius Ladder graph, Flag graph, Tadpole graph, Lollipop graph, n-Barbell graph, Butterfly graph, Crown graph have been considered and the star edge chromatic number χ_E is obtained for such graphs.

It is proved that for given positive integers n,m

$$i) \chi_E((k_{1,n}; k_{1,m})) = \begin{cases} m + 1 & \text{if } m > n \\ n + 1 & \text{if } n > m. \end{cases}$$

$$ii) \chi_E(P_n^+) = \begin{cases} 3 & \text{if } n \leq 4. \\ 4 & \text{if } n > 4. \end{cases}$$

$$iii) \chi_E(M_n) = n + 3 \text{ if } n \geq 2$$

$$iv) \chi_E(Fl_n) = \begin{cases} 3 & \text{if } n = 3 \\ 4 & \text{if } n \geq 4 \end{cases}$$

$$v) \chi_E(T_{m,n}) = 4 \text{ if } m \geq 3, n \geq 2$$

$$vi) \chi_E(L_{(m,n)}) = m + 1 \text{ if } m \geq 3, n \geq 2$$

$$vii) \chi_E(n, \text{ barbell graph}) = \begin{cases} 4 & \text{if } n = 3 \\ n + 2 & \text{if } n \geq 4 \end{cases}$$

Keywords: Edge Coloring, Star edge coloring, Star edge Chromatic Number.





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INTRODUCTION

All graphs considered here are finite, simple undirected connected graphs.

$B_{n,m}$ Graph [11]

The graph $B_{n,m}$ [11] is the graph obtained by joining the center u of the star $K_{1,n}$ and the center v of another star $K_{1,m}$ to a new vertex w . It is denoted by $\langle K_{1,n}, K_{1,m} \rangle$

Comb Graph [11]

The comb $P_n \odot K_1$ [11] is the graph obtained from the path P_n by attaching pendant edge at each vertex of the path. It is also denoted by P_n^+ .

Mobius Ladder Graph [11]

The mobius ladder M_n [11] is the graph obtained from the ladder $P_n \times P_2$ by joining the opposite end points of the two copies of P_n .

Flag graph Fl_n [11]

The flag Fl_n [11] is obtained by joining one vertex of C_n to an extra vertex called the root.

Tadpole Graph [11]

The (m, n) - tadpole graph [11] also called a dragon graph, is the graph obtained by joining a cycle graph C_m to a path graph P_n with a bridge.

Lollipop graph [11]

The (m, n) - lollipop graph [11] is the graph obtained by joining a complete graph K_m to a path P_n with a bridge.

n-Barbell graph[11]

n- barbell graph is the simple graph obtained by connecting 2 copies of complete graph K_n by a bridge. Through this area in multidimensions. It has many applications in various fields, one such application is estimation of sparse hessian matrix using coloring technique. The applications in various fields motivated me to do this work.

Star Edge Coloring of some simple Graphs

Star edge coloring of Bistar graph (B_n, m)

Theorem 2.1.1:

For given positive integers n, m

$$\chi_E((k_{1,n}; k_{1,m})) = \begin{cases} m + 1 & \text{if } m > n \\ n + 1 & \text{if } n > m. \end{cases}$$

Proof:

$B_{n,m}$ has $n+m+3$ vertices and $n+m+2$ edges.

The pendent Edges of n and m are colored with different colors.

The edge connects pendent edges with the graph is colored with another two different colors except the pendent edge colors.

Irrespective of n and m , B_n, m is star edge colored with $m+1$ color if $m>n$, and also, it is star edge colored with $n+1$ color if $n>m$





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Hence

$$\chi_E(\langle k_{1,n}; k_{1,m} \rangle) = \begin{cases} m + 1 & \text{if } m > n \\ n + 1 & \text{if } n > m. \end{cases}$$

Illustration 2.1.1

The Star edge coloring of $\langle k_{1,n}; k_{1,m} \rangle$ is as follows. Here m and n are equal

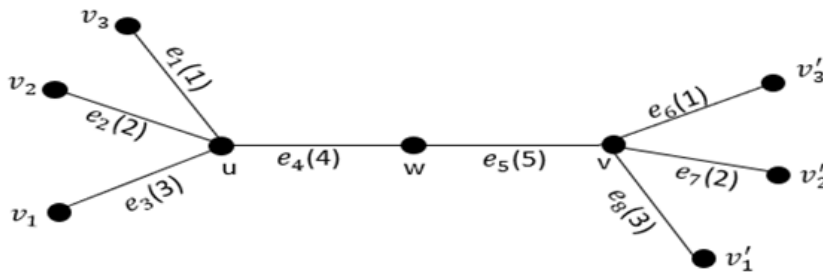
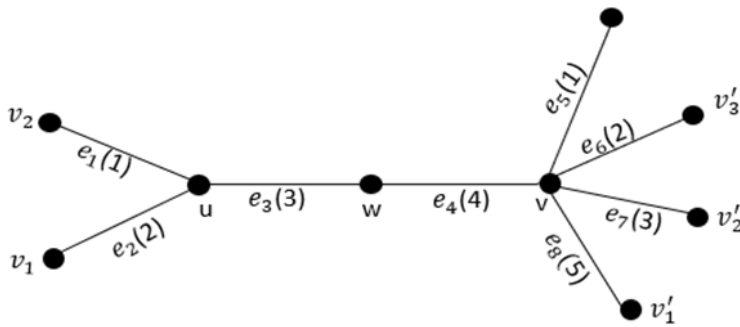


Illustration 2.1.2

The Star edge coloring of $\langle k_{1,n}; k_{1,m} \rangle$ is as follows. Here m and n are not equal (i.e.) n=2 and m=4



Therefore $\chi_E(\langle k_{1,2}; k_{1,4} \rangle) = 5$

Star Edge Coloring of Comb Graph (P_n)

Theorem 2.2.1:

For given positive integers $n \geq 5$ $\chi_E(P_n^+) = \begin{cases} 3 & \text{if } n \leq 4. \\ 4 & \text{if } n > 4. \end{cases}$

Proof

P_n^+ has $2n$ vertices and $2n-1$ edges. The pendant edges are $e_1, e_2, e_3 \dots e_n$ and the edges adjacent to it are

$e_{n+1}, e_{n+2}, e_{n+3} \dots e_{2n-1}$.

The edge colors are $e_1, e_2, e_3 \dots e_n, e_{n+1}, e_{n+2}, e_{n+3} \dots e_{2n-1}$ denoted by $C(E_i)$ where $i = 1, 2, 3, \dots, n, n+1, \dots, 2n-1$.

The star edge coloring pattern for $n \leq 4$ is as follows:

$$C(E_i) = \begin{cases} 1 & \text{if } i = 1, 2, 3 \\ 2 & \text{if } i = 4, 6 \\ 3 & \text{if } i = 5 \end{cases}$$

The star edge coloring pattern for $n > 4$ is as follows:

$$C(E_i) = \begin{cases} 1 & \text{if } i = 1, 2, 3 \\ 2 & \text{if } i \equiv 0 \pmod{3} \\ 3 & \text{if } i \equiv 1 \pmod{3} \\ 4 & \text{if } i \equiv 2 \pmod{3} \end{cases}$$

Hence, the star edge chromatic number of P_n^+ is



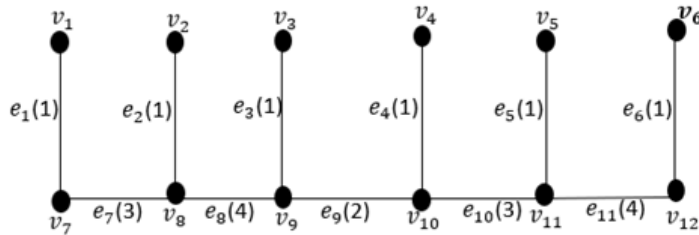


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$$\chi_E(P_n^+) = \begin{cases} 3 & \text{if } n \leq 4. \\ 4 & \text{if } n > 4. \end{cases}$$

Illustration 2.2.1.

The star edge coloring of P_6^+ is as follows



Hence $\chi_E(P_6^+) = 4$

Star Edge Coloring of Mobius Ladder Graph (M_n)

Theorem 2.3.1:

For given positive integers n , $\chi_E(M_n) = n + 3$ if $n \geq 2$

Proof

M_n has $2n$ vertices and $5n-4$ edges. Let the vertices be considered in two layers as

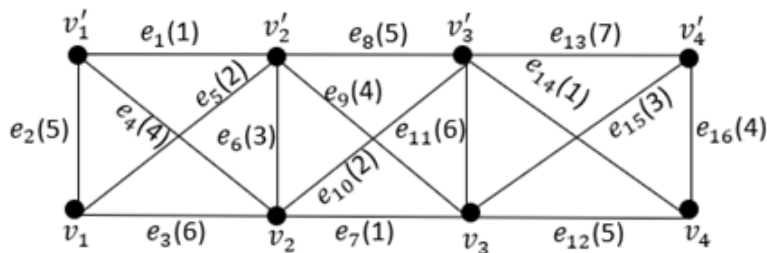
V_1, V_2, \dots, V_n and V'_1, V'_2, \dots, V'_n respectively.

Let e_i denote the edges where $i = 1, 2, 3 \dots n$. we consider n vertices assigned the star edge coloring of the graph with $n+3$ colors if $n \geq 2$.

Hence $\chi_E(M_n) = n + 3$ if $n \geq 2$.

Illustration 2.3.1

The star edge coloring of M_n is as follows



Therefore $\chi_E(M_4) = 7$

Star Edge Coloring of Flag Graph (Fl_n)

Theorem 2.4.1

For given positive integers n , $\chi_E(Fl_n) = \begin{cases} 3 & \text{if } n = 3 \\ 4 & \text{if } n \geq 4 \end{cases}$

Proof

A Flag graph has $n+1$ vertices and $n+1$ edge.

Let $e_1, e_2, e_3 \dots e_n, e_{n+1}$ denotes the edges of Fl_n and e_n connects C_n to the root edge e_{n+1} .





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Let E_i denotes the edges of Fl_n where $i = 1, 2, 3, \dots, n+1$ and $C(E_i)$ denote the color of E_i .

The edge coloring pattern is discussed as follows if $n=3$.

$$C(E_i) = \begin{cases} 1 & \text{if } i = 1, 4 \\ 2 & \text{if } i = 3 \\ 3 & \text{if } i = 2 \end{cases}$$

Then the root edge is colored with anyone of that color.

The edge coloring pattern is discussed as follows if $n \geq 4$.

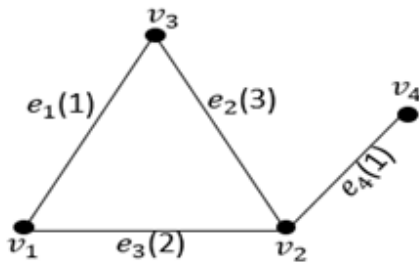
$$C(E_i) = \begin{cases} 1 & \text{if } i \equiv 0 \pmod{4} \\ 2 & \text{if } i \equiv 1 \pmod{4} \\ 3 & \text{if } i \equiv 2 \pmod{4} \\ 4 & \text{if } i \equiv 3 \pmod{4} \end{cases}$$

We consider the star edge coloring of the graph has $n \geq 4$ vertices, we have to assign four different colors to the edges and the root edge colored with anyone of the four colors.

Hence $\chi_E(Fl_n) = \begin{cases} 3 & \text{if } n = 3 \\ 4 & \text{if } n \geq 4 \end{cases}$

Illustration 2.4.1

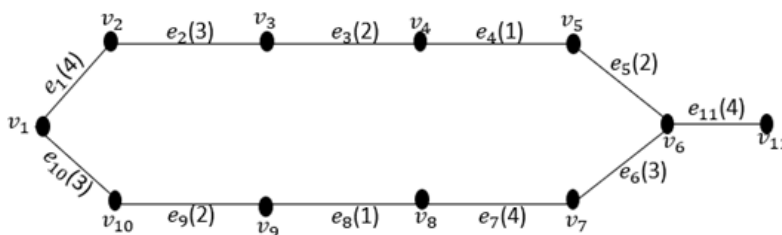
The star edge coloring of Fl_n is as follows.



Hence $Fl_3 = 3$

Illustration 2.4.1

The star edge coloring of Fl_{10} is as follows.



Hence $Fl_{10} = 4$

Star Edge Coloring of Tadpole Graph ($T_{m,n}$)

Theorem 2.5.1:

For given positive integers $m \geq 3, n \geq 2$, the star coloring of Tadpole graph

$\chi_E(T_{m,n}) = 4$ if $m \geq 3, n \geq 2$

Proof

A tadpole graph has $m+n$ vertices and $m+n$ edges. Let $e_1, e_2, e_3 \dots e_m, e_{m+1}, e_{m+2}, \dots, e_{m+n}$ be the edges of $T_{m,n}$ and denotes the color of $C(E_i)$ of E_i .





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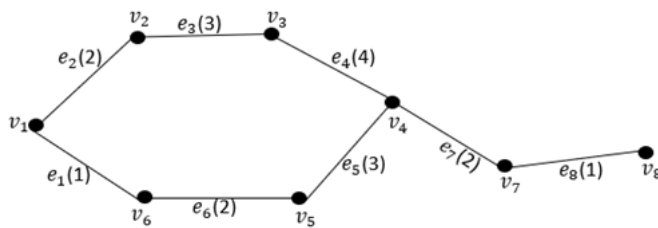
The Star edge coloring of the cyclic graph is colored with four different colors and also, we assign same colors to the path graph P_n with bridge.

Therefore, the star coloring of Tadpole graph

$$\chi_E(T_{m,n}) = 4 \text{ if } m \geq 3, n \geq 2.$$

Illustration 2.5.1

The star edge coloring of $T_{6,2}$ is as follows



Hence $\chi_E(T_{6,2}) = 4.$

Star Edge Coloring of Lollipop Graph ($L_{m,n}$)

Theorem :2.6.1

For given positive integers m, n for every $m \geq 3, n \geq 2$

$$\chi_E(L_{(m,n)}) = m + 1$$

Proof

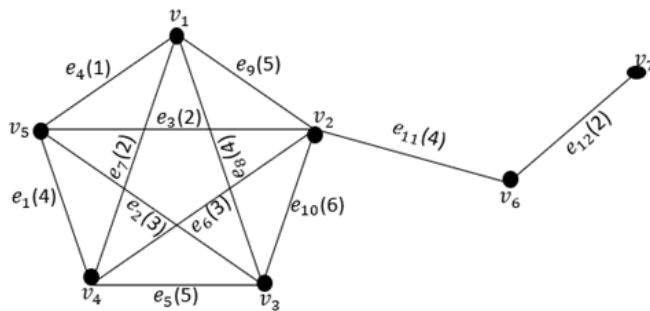
The (m,n) -lollipop graph has $m+n$ vertices and $\binom{m}{2} + n$ edges. As m is complete we need 'm' colors irrespective of n , the same colors used in 'm' is repeated to color 'n'.

'm+1' colors are needed to star edge color $L_{m,n}$.

$$\chi_E(L_{(m,n)}) = m + 1 \text{ if } m \geq 3, n \geq 2.$$

Illustration 2.6.1

The star edge coloring of $L_{5,2}$ is as follows



Hence $\chi_E(L_{(5,2)}) = 6$





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Star edge coloring of n- Barbell Graph.

Theorem 2.7.1:

For given positive integer n,

$$\chi_E(n, \text{barbell graph}) = \begin{cases} 4 & \text{if } n = 3 \\ n + 2 & \text{if } n \geq 4 \end{cases}$$

Proof

Let G and G' be an n- barbell graph which has 2n vertices and $2 \binom{n}{2} + 1$ edges.

To Star edge color G and G' are the simple graph obtained by connecting 2 copies of complete graph K_n , by a bridge.

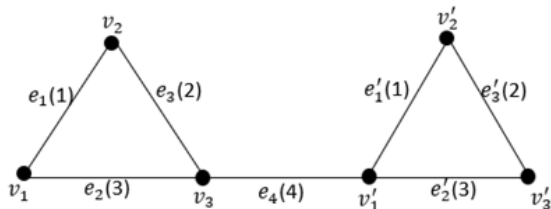
First edge color to G with different colors and also assign same edge color to G'.

By connecting the complete graph G and G', we assign different color to a bridge.

Hence $\chi_E(n, \text{barbell graph}) = \begin{cases} 4 & \text{if } n = 3 \\ n + 2 & \text{if } n \geq 4 \end{cases}$

Illustration 2.7.1:

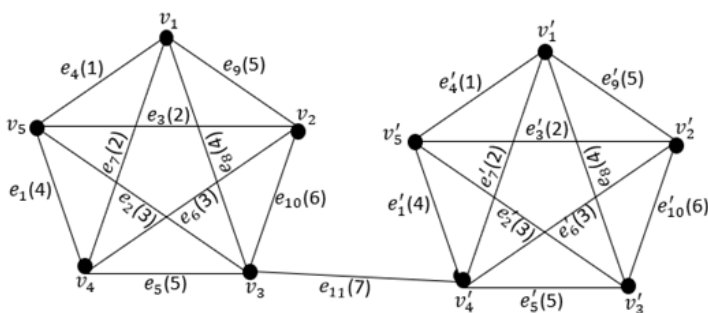
The star edge coloring of 3-Barbell graph is as follows



Hence $\chi_E(3, \text{barbell graph}) = 4$

Illustration 2.7.2

The star edge coloring of 5-Barbell graph is as follows.



Hence $\chi_E(5, \text{barbell graph}) = 7$

CONCLUSION

In this paper, it is proved that the star edge coloring pattern of some simple graphs such as Bistar graph, Comb graph, Mobius Ladder graph, Flag graph, Tadpole graph, Lollipop graph, n-Barbell graph, have been obtained and also the star edge chromatic number χ_E is obtained for such graphs. It is proved that for given positive integers n, m.





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$$\begin{aligned}
 \text{i) } \chi_E((k_{1,n}; k_{1,m})) &= \begin{cases} m + 1 & \text{if } m > n \\ n + 1 & \text{if } n > m. \end{cases} \\
 \text{ii) } \chi_E(P_n^+) &= \begin{cases} 3 & \text{if } n \leq 4. \\ 4 & \text{if } n > 4. \end{cases} \\
 \text{iii) } \chi_E(M_n) &= n + 3 \text{ if } n \geq 2 \\
 \text{iv) } \chi_E(Fl_n) &= \begin{cases} 3 & \text{if } n = 3 \\ 4 & \text{if } n \geq 4 \end{cases} \\
 \text{v) } \chi_E(T_{m,n}) &= 4 \text{ if } m \geq 3, n \geq 2 \\
 \text{vi) } \chi_E(L_{(m,n)}) &= m + 1 \text{ if } m \geq 3, n \geq 2 \\
 \text{vii) } \chi_E(n, \text{ barbell graph}) &= \begin{cases} 4 & \text{if } n = 3 \\ n + 2 & \text{if } n \geq 4 \end{cases}
 \end{aligned}$$

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A Time-Line Review on Solar Flare and Its Effects on Solar Atmosphere

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ABSTRACT

A solar flare is a powerful release of radiation resulting from the discharge of magnetic energy associated with sunspots. Solar flares are the most explosive events in our solar system, appearing as bright regions on the Sun and varying in duration from minutes to hours. In the extensive period of the solar 11-year cycle basically the sunspots, solar flares, prominences and massive CMEs has been coming frequently. The extensive flares and its associated CMEs may intervene the processes of the ionosphere and induce currents in the geomagnetic fields. Hence an exploratory review on this aspect will light into the phenomenon of the generation of solar flare and its associated solar atmospheric perturbations. In this work we have done review on the earlier invention on the solar flare and associated events like relationship with ionospheric events and geomagnetic field variations, radio blackout for shortwave fading, categorization of the flares and high energy particle acceleration etc. and these show a deep inside into the solar flare events from the perspective of atmospheric outer layers.

Keywords: solar flare, CMEs, ionosphere, solar flares events, solar quiet current

INTRODUCTION

Solar flares are strongly connected to the coronal mass ejections (CMEs), in which solar magnetic fields and their embedded particles are expelled into interplanetary space and the solar environment. In the Earth's ionosphere, a dynamo process occurs due to the flow of plasma current, leading to the generation of a magnetic field [1,2]. During the variability of the solar magnetic fields and changes in proton density the dynamo process can be disrupted. Solar flares are often directed towards Earth, leading to disturbances in our planet's atmosphere. In recent decades, an increase in the solar activity is noticed, as the Sun approaches the peak of its 11-year solar cycle, with the year 2022 experiencing particularly pronounced flaring events. Solar flares are resulted from continuous bursts of magnetic



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activity in the solar corona, launching solar plasma and magnetic fields into interplanetary space. When these solar ejecta collide with Earth's magnetic field, they can trigger geomagnetic storms [3-5]. Differential solar heating drives atmospheric tidal winds that move ionospheric plasma along geomagnetic field lines, generating electric fields and currents, akin to a dynamo coil moving within a magnetic field. This region is known as the ionospheric dynamo region. The magnetic effects of these electric currents can be observed on the ground during magnetospheric calm conditions. Additional electric currents are generated by varying magnetospheric electric convection fields, leading to phenomena such as auroral electrojets and polar currents [6]. During a solar flare, bursts of solar radiation from active sunspots reach higher altitudes in the atmosphere, particularly in the E and D layers. This results in an increased electric conductivity and enhancement of the solar quiet (Sq) current, generating a minor increase known as the geomagnetic solar flare effect [7]. Earlier studies have reported that geomagnetic disturbances are caused by enhanced solar wind magnetospheric energy coupling processes. The primary driver of geomagnetic disturbances is magnetic reconnection, which establishes an electro-dynamic connection between solar wind plasma and the Earth's magnetosphere. The effects of solar flare induced geomagnetic disturbances and their impacts on Earth's atmospheric electricity at high and mid-latitudes were explored in different researches. [8-11]. In this work we are considered a time line review of the solar flare and its related events like the observation of white light as Carrington's events and Fleming and McNish attributed the geomagnetic maps and other most significant observations like polar cap absorptions, high energy proton accelerations, radio blackout, change of plasma dynamics of the ionospheric D, E and F layers during solar flare, total geomagnetic field variations, geomagnetic field variation at the solar flare peninsula developed by considering the past to present time over the globe and the lines on the globe. This review resulted into a salient understanding of the geomagnetic field variation during the solar flares at its comparable intensities on various parts of the globe.

Earlier Studies on solar flare and its effects on solar atmosphere

In the early 1660s, Isaac Newton demonstrated that sunlight can be divided into distinct colors using a glass prism. In 1800, William Herschel expanded on this by discovering unseen "rays" beyond the red end of the spectrum, which he identified as infrared radiation after detecting a rise in temperature. Johann Wilhelm Ritter, a year later, discovered ultraviolet radiation by observing the blackening of silver chloride paper beyond the violet end of the spectrum. UV radiation was independently confirmed by William Hyde Wollaston. Early ionospheric research established that intense solar flares significantly impact the Van Allen belts and ionospheric layers, disrupting current flows in the ionospheric plasma [12, 13]. It is seen that there are fifty remarkable strongest flares are happened 1997 to 2017 during this 20 years span. Among them the lowest amplitude achieved was X2.6 (0.00026 Watts per m²) and highest amplitude achieved was X28+ (0.0028 Watts per-m² +) along with the average of X6.2 (0.000624 Watts per-m²). The following review study from the years 1860 to 2023 will highlight significant researches on solar flares and their effects on the solar atmosphere.

1859-1900: Key solar flare observations and ionospheric predictions

Richard C. Carrington and Richard Hodgson independently observed a solar flare on September 1, 1859. Carrington later linked this event to simultaneous geomagnetic variations recorded at Kew Observatory, marking the first recognized connection between solar flares and geomagnetic effects [14,15].

1901-1937: Early ionospheric and solar flare studies

The ionosphere's existence was theorized based on scientific research in 1902[16]. After that Studies began to explore the impact of solar flares on Earth's magnetic field through global models, focusing on the time-based development of electric currents generating solar flare effects (sfes)[17,18].

1926-1950: Advances in solar flare research

Researchers noted a rise in electron density during solar flares, leading to radio signal fade-outs [19]. By 1935, the correlation between high-frequency radio signal fading and chromospheric flares was established [20], with further studies in 1936 and 1937 confirming the link between radio signal attenuation and geomagnetic variations along with the inventions of multi-frequency ionosonde, geomagnetic maps by Fleming and Mc-Nish, telluric currents



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fluctuations and intensification of diurnal current [21-24]. The correlation between solar cycle curves and flare frequency by “Wolf’s number” was recognized in 1947 [25]. Rocket technology confirmed the localization of ionospheric dynamo currents in the E-region and Post flare surge in cosmic ray intensity level was observed at the F-region in early 1950’s [26,27]. Intensified ionosphere penetration by flare proton particles at the polar region due to Polar cap Absorptions with geosynchronous proton with minimum velocity as $15G_eV\cos^4\theta$ (θ : magnetic latitude) was observed [28].

1951-1975: Solar flare effects and geomagnetic research

In 1951, X-rays were detected during low solar activity, recognized as the primary ionizing agent in solar flares, with wavelengths between 1 to 100 Å [29]. In 1952, it was reported that the onset of solar flares and geomagnetic impacts could be explained by ionospheric electromagnetic induction, with unusually high H-component magnetic crochets magnitudes observed at Huancayo and other low-latitude stations [30]. Solar flares ionized the D-region, primarily through Lyman series absorptions as reported in 1954. Studies linked solar flares to geomagnetic changes, solar quiet currents (Sq), and sudden appearances of auroras [31]. Subsequent Studies showed that geomagnetic changes during solar flares are influenced by multiple factors beyond just the increase in solar quiet current (Sq) [32]. High-intensity solar flares on the solar limb, detected through the Ha line in the Balmer series, were often associated with sfe occurrences. Statistical analyses confirmed solar flare impacts on the F₂-layer [33,34]. The definition of sfe was formalized at the 1957 Copenhagen Symposium, and a provisional atlas was presented at the 1959 Utrecht Symposium [35]. Magnetic data from the 1957 International Geophysical Year were analysed. Magnetic crochets were linked to massive solar flares [36,37]. Ionospheric current systems below the dynamo layer were found responsible for geomagnetic effects, revealing asymmetry in current circuits across hemispheres [38]. Solar flare effects (sfes) were characterized through ground-level enhancements (GLEs) and polar cap absorption (PCA) events during mid-sixty’s [39]. Sfe intensity varied globally, linked to vortex migration during flares. Phase shifts between crochet currents and other ionospheric perturbations showed direct correlations [40]. Unusual ionospheric impacts in Brazil during the 1966 flare were studied [41]. Magnetic crochets correlated with radio bursts above 4995 MHz [42]. The X-ray radiation from flares caused sudden ionospheric disturbances (SID), impacting communication [43]. Counter-currents in equatorial regions during sfes were noted [44]. Significant X-ray and microwave bursts were required to trigger sfe events, studied through occurrences in Kodaikanal (1966-1971)[45].

1976-2000: Technological advances and new insights

Research highlighted plasma density increases due to shock compression and successful radio communication during solar events [46,47]. Investigations into the relationship between interplanetary fields, magnetopause reconnection and longitudinal lagging of the sfe current from the Sq current system (found as 15-30°) were advanced by GPS technology [48-51]. Various phenomena such as wave-particle interactions and energetic storm particles (ESPs) accelerated at ICME shocks were studied, showing that distinct particle populations could trigger visible light. ICME shocks compressing the dayside magnetosphere led to sudden auroras and increased ionization in the auroral zone. The impact of solar flares on Indo-USSR magnetic observatories (0-45N) was analysed, focusing on electrojets. Solar flare effects (sfe) peaked midday at equatorial latitudes with positive H variations. Advancements in GPS technology enhanced the study of sfe through ground and satellite receivers, with TEC enhancements noted during the daytime. Space weather models improved the understanding and prediction of energetic particle impacts [52-54].

2001-present: Analysis of solar flares data collected from SOHO, GEOS, TIMED, and GPS receivers

It was reported in 2004 that stronger solar flares generally have steeper X-ray spectra. While X-ray fluxes during flares can vary by several orders of magnitude, EUV fluxes show less variation. Similar flares from the same active region in 2003 were studied to assess their maximum intensity [55,56]. The ionospheric effects of several powerful solar flares were studied using data from SOHO, GEOS, TIMED, and GPS receivers. The study found that the X17 flare on October 28, 2003, had the most significant impact on the dayside ionosphere, causing a peak increase of about 25 TECU [57]. TEC data on October 29, 2003, was deemed unsuitable as a background for flare events due to contamination from an interplanetary coronal mass ejection (ICME) that caused a geomagnetic storm [58]. It was noted that while EUV and X-ray emissions from solar flares impact the dayside ionosphere, SEPs affect the entire



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globe, particularly at high latitudes and Polar Regions. Differentiating between the effects of SEPs and the electromagnetic components of solar flares requires understanding their impact on both the day-side and night-side ionosphere [59]. Increased ionization from solar flares was found to be influenced by the magnetic link to Earth and the energy distribution of solar flare particles. Energetic particles penetrating the lower atmosphere generate HO_x and NO_x, which act as catalysts that degrade ozone [60]. The magnitude of the X-ray flare during the solar perturbation was estimated using riometer data and galactic radio signal background attenuation, with the highest flux observed at 4.0 milli-Watt per square meter for an X40 class flare [61]. The peak magnitude of the November 4, 2003, solar flare was determined by analysing ionosphere perturbations, concluding that the flare reached its maximum intensity with an estimated magnitude of X45 ± 5 [62].

Advanced studies and developments in solar flare impact analysis (from 2006)

It was observed that electron fluxes showed similar signs for solar energetic particle (SEP) events and magnetic storms. The study proposed differentiating these responses using K_p activity indices and measurements of energetic particle fluxes, particularly with data from the EPAM instrument on NASA's ACE spacecraft [63,64]. Further investigations were conducted on the behaviour of the ionosphere in response to X-ray emissions and solar energetic particles during solar flares. The findings suggested that the magnitude of the Carrington flare was comparable to the November 4, 2003, flare [65]. The SRMV was established to characterize temporary variations in Earth's geomagnetic field. The Ebro Observatory took the lead in managing this service, which was initially conceived during the Assembly of Rome in 1954 under Committee No.10 [66]. Information was gathered about the interplanetary causes of ionospheric disruptions at middle latitudes. A solar flare detector utilizing GPS capabilities to monitor total electron content (TEC) was developed, allowing automatic detection of sudden changes in ionospheric ionization [67-69]. The investigation of a solar flare event on the dayside of the geomagnetic field revealed distinct signals at multiple stations located simultaneously in the dark region [70-76].

The ionospheric impact of solar flares was studied through the analysis of vertical total electron content (vTEC) data collected from GPS in 2009. It was found that detecting solar flare effects is influenced by both the distance from the sub-solar point and the intensity and position of overhead currents [77]. The onset of relativistic electron acceleration at the flare site was often delayed by 5 to 15 minutes after the flare, in addition to any propagation delays. This delay was observed in the events of October 28 and 29, 2003, but not in the July 14, 2000, event [78,79]. A modelling tool called the Particle Acceleration and Transport in the Heliosphere (PATH) code was designed to simulate the radiation environment generated by SEP events at Earth's orbit [80-82]. An empirical correlation between solar flare events (SFEs) related magnetic field variations and X-ray flux was established in 2010 using over 300 SFE observations. This relationship helped estimate the magnitude of the Carrington flare as approximately X42 to X48, depending on the location of observations [83]. Detection of X-ray solar flares were influenced by factors including flare intensity, growth rate, and the location of geomagnetic observatories. Faster growth in radiation and observatories in the summer hemisphere facilitated easier detection, while pre-existing geomagnetic disturbances also played a role. An analysis of coronal mass ejection (CME) speeds and equatorial current systems estimated a 12% chance of an extreme space weather event occurring within the next decade. Extreme geomagnetic activity was estimated to occur once every 100 to 200 years [84-86]. The Royal Academy of Engineering in 2013 investigated that a super-storm would occur approximately once every 79 years [87]. Analysis of very low frequency (VLF) amplitude changes showed that electron density in the ionosphere's D-region could increase up to 80 times compared to normal values during solar flares. The horizontal magnetic field, at the Tirunelveli equatorial station increased by up to 8.5% for M-class flares [88].

Mechanisms and innovations

During 2016 -2017 the studies focussed on how Earth's magnetic field responds to significant energy releases, focusing on the decay of SFEs. It was found that decay time depends on the balance of X-ray and UV contributions, and only the most energetic X-ray periods lead to observable SFEs [89]. An estimated recurrence interval for a flare with intensity similar to the Carrington event was calculated to be around 90 years. SFEs could manifest in various magnetic components with unpredictable and irregular shapes, including steep or smooth profiles depending on



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solar disturbance [90]. Approximately 33% of land-based geomagnetic variations were linked to Earth's interior, comparable to Sq and other temporary geomagnetic changes [91-93]. Researchers created an SFE index to isolate SFE signals from natural variations. This index, based on the radial influence of SFE disturbances, led to the development of a detector currently in testing [94]. The vertical incidence sounder at the Ebro Observatory analysed the effects of X9 flares on the magnetic field and ionosphere, highlighting its usefulness for detecting solar flares in 2018. The effects of space-temporal geophysical disturbances on GNSS positioning accuracy were studied. Variations in the lower ionosphere were related to the "magnetic crochet" effect, later termed "solar flare effect" (SFE) [95,96]. A solar flare monitor using GNSS was built and calibrated to detect ionospheric ionization from solar flares. An 11-year analysis (2008-2018) was conducted to optimize the GNSS and SFE detector, aligning with SFE lists from the International Service of Rapid Magnetic Variations (SRMV) [97]. Annual bulletins from the International Association of Geomagnetism and Aeronomy (IAGA) included references to global magnetic activity indices and sudden variations in the field, specifically related to SFEs from 2023[98-101].

CONCLUSIONS

In this study the relationship among the various phenomenon related to the solar flare are considered. Here various kinds of sfe were considered *w.r.t.* variation in their time of happening. The findings of the earlier researches on the relationship of the changes occurred in the conditions of the parameters in the atmospheric layers like ionospheric D, E and F along with their electron content, solar quiet current variations, geomagnetic field variations, intensity scaling of the flares are listed in details. The present review showed that there is a certain variation of ionosphere content and geomagnetic field in effect which related to short signal radio fade out at large. The question of finding variation of the coupling of ionosphere and troposphere during the flare is being still unsolved. The ionospheric parameters like total electron content, plasma frequency of the ionospheric F₂ layer, electron densities of F₂ layer, geomagnetic parameters like K_p, A_p, C_p and Dst and the solar parameters like interplanetary magnetic field, solar wind and radiation flux as received from the satellite radio can be taken into consideration. The tropospheric and surface data on pressure, temperature and humidity for strong to very intensive flare may be considered in future analysis to get into pre, post and control conditions during the solar flare events. If this above mentioned processes of thorough researches can be carried out then a scope to find the coupling of the troposphere and the ionosphere can be found.

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Table: 1 Details of the Solar Flare happened last 15 years period

Sl.No.	Date	Sunspot number	New regions	Background flux	Maximum flux	Classes of Flare		
						C	M	X
1	04-11-2003	79	1	C2.3	X17.4	3	3	1
2	02-04-2001	223	1	C6.5	X17.1	2	4	3
3	28-10-2003	230	1	C3.2	X17.2	5	0	1
4	07-09-2005	11	1	C1.0	X17.1	4	0	1
5	15-04-2001	100	0	B5.5	X14.5	7	0	1
6	29-10-2003	330	0	C3.3	X10.1	4	2	1
7	06-11-1997	60	0	B9.7	X9.08	3	0	1
8	05-12-2006	59	0	B4.1	X9.06	9	1	1
9	02-11-2003	174	0	C1.9	X8.38	1	2	1
10	10-09-2017	38	1	B4.9	X8.28	4	0	1
11	20-01-2005	61	0	B8.7	X7.11	5	0	1
12	09-08-2011	54	0	B4.3	X7	5	1	1
13	06-12-2006	44	0	B5.3	X6.58	13	3	1
14	09-09-2005	59	0	B8.3	X6.21	7	5	3
15	13.12.2001	212	3	C2.1	X6.22	4	2	1





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16	14.08.2000	243	2	C2.9	X5.75	4	2	1
17	06-04-2001	136	0	C3.3	X5.66	3	0	1
18	07-03-2012	102	0	C1.1	X5.43	1	0	2
19	25-08-2001	132	1	C7.2	X5.4	17	2	1





Fuzzy Soft Hyponormal Operators

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ABSTRACT

In this paper, we introduce the concept of Fuzzy Soft Hyponormal operators (FSHN-operators) in Fuzzy Soft Hilbert spaces (FSH-spaces), built from a family of operators and some elementary properties of these operators are studied. In addition, some relations between FSHN-operators and Fuzzy Soft Normal operators (FSN-operators) in FSH-spaces are obtained from Fuzzy Soft Self-Adjoint (FSSA), Fuzzy Soft Unitary (FSU), invertible and unitary equivalent.

Keywords: Fuzzy Soft Hyponormal operators (FSHN-operators), Fuzzy Soft Hilbert spaces (FSH-spaces), FSHN-operators, Fuzzy Soft Self-Adjoint (FSSA), Fuzzy Soft Normal operators (FSN-operators) and Fuzzy Soft Unitary (FSU).

INTRODUCTION

In 1999, Molodtsov[2] introduced soft set theory as a different method for vagueness. Majiet. al. [16] defined new notions of soft set theory. Fuzzy soft set which is a combination of fuzzy and soft sets was first introduced by Maji et.al. [11]in 2001. In recent years, many researchers applied this notion and gave some concepts such as fuzzy soft point, fuzzy soft metric spaces and fuzzy soft normed spaces[3],[4]. In 2013, Zadeh[14] coined fuzzy soft norm over a set and established the relationship between fuzzy soft norm and fuzzy soft norm over a set. NashatFaried et al. [1] introduced the fuzzy soft inner product on fuzzy soft vector space and its properties. Also, they have given the definition of fuzzy soft Hilbert spaces [7]. In addition, they continued by defining the fuzzy soft linear operators in fuzzy soft Hilbert space with their related theorems including spectral theory in 2020 [8]. After that, they defined the fuzzy soft self adjoint operator [8] and studied its properties. In 2021, a new type of normal operator, called fuzzy soft





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normal operator has been introduced by SalimDawood et al. [13] and some theorems relating to this operator with some properties are given. Also, the relation between this operator and other types like fuzzy soft self-adjoint operator are studied. In 2022, NashatFariet et al. [12] have given the definition of fuzzy soft unitary operator, a particular sort of the fuzzy soft linear operators in fuzzy soft Hilbert space. In addition, the connection between the fuzzy soft unitary operators and each of the fuzzy soft isometry operators and the fuzzy soft normal operators are established. The aim of this work presents the concept of fuzzy soft hyponormal operators and some elementary properties. Furthermore, some relations between FSHN-operators and Fuzzy Soft Normal operators (FSN-operators) in FSH-space are obtained from Fuzzy Soft Self-Adjoint (FSSA), Fuzzy Soft Unitary (FSU), invertible and unitary equivalence.

PRILIMINARIES

Definition 2.1: [14]

Let \tilde{A} be a fuzzy set over universal set U , a set characterized by a membership function $\mu_{\tilde{A}}:U \rightarrow I$, where $I=[0,1]$ and \tilde{A} represented by an ordered pairs $\tilde{A} = \{(u, \mu_{\tilde{A}}(u)) : u \in U, \mu_{\tilde{A}}(u) \in I\}$ or $\tilde{A} = \{\frac{\mu_{\tilde{A}}(u)}{u} : u \in U\}$
 $\mu_{\tilde{A}}(u)$ is said to be degree of membership of u in \tilde{A}
 And $I^U = \{\tilde{A} : \tilde{A} \text{ is a function from } U \text{ into } I\}$

Definition 2.2:[2]

Let U be a universal set and E be set of parameters. $P(U)$ the power set of U and $A \subseteq E$. Suppose that \mathcal{G} is a mapping given by $\mathcal{G}:A \rightarrow P(U)$, where $\mathcal{G}_A = \{\mathcal{G}(e) \in P(U) : e \in A\}$. The pair (\mathcal{G}, A) or \mathcal{G}_A is called soft set over U with respect to A .

Definition 2.3: [11]

The soft set (\mathcal{G}, A) is called fuzzy soft set (**FS-set**) over a universal set U , whenever \mathcal{G} is a mapping $\mathcal{G}:A \rightarrow I^U$, and $\{\mathcal{G}(e) \in I^U : e \in A\}$. The family of all FS-sets, symbolized by $FSS(\tilde{U})$

Definition 2.4:[3]

The FS-set $(\mathcal{G}, A) \in FSS(\tilde{U})$ is called fuzzy soft point over U , symbolized by $(u, \mu_{\mathcal{G}(e)})$ if $e \in A$ and $u \in U$.
 $\mu_{\mathcal{G}(e)} = \begin{cases} \lambda, & \text{if } u = u_0 \in U \text{ and } e = e_0 \in A \\ 0, & \text{if } u \in U - u_0 \text{ or } e \in A - e_0 \end{cases}$, where $\lambda \in (0,1)$

Remark 2.5:[3]

$C(A)$ is the family of all FS-Complex numbers and $R(A)$ is also the family of all FS-Real numbers

Definition 2.6:[7]

Let $(\tilde{H}, \tilde{N}, *)$ and $(\tilde{H}', \tilde{N}', *)$ be FSN-spaces. A fuzzy soft linear operator $\tilde{T} : (\tilde{H}, \tilde{N}, *) \rightarrow (\tilde{H}', \tilde{N}', *)$ is said to be fuzzy soft bounded iff $\exists c > 0, \exists$ for each $i > 0, \tilde{N}'(\tilde{T}\tilde{x}, \tilde{t}) \geq \tilde{N}(\tilde{x}, \frac{\tilde{t}}{c}) \forall \tilde{x} \in \tilde{H}$.

Remark 2.7.[7]

Let $\tilde{B}(\tilde{H})$ be the set of all Fuzzy soft bounded (continuous) linear operators (FSB-operator) on \tilde{H} .

Theorem 2.8; [7]

Let $(\tilde{H}, \tilde{F}, *)$ be a FSH-space. Let $\tilde{T} \in \tilde{B}(\tilde{H})$ be $\tau_{\tilde{F}}$ - continuous linear functional. Then \exists a unique $\tilde{T}^* \in \tilde{B}(\tilde{H})$ such that $\langle \tilde{T}\tilde{x}, \tilde{y} \rangle = \langle \tilde{x}, \tilde{T}^*\tilde{y} \rangle, \forall \tilde{x}, \tilde{y} \in \tilde{H}$.

Note 2.9: [7]

The adjoint of \tilde{T} . i.e. \tilde{T}^* is a unique linear operator on \tilde{H} with the relation $\langle \tilde{T}\tilde{x}, \tilde{y} \rangle = \langle \tilde{x}, \tilde{T}^*\tilde{y} \rangle$





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Definition 2.10:[8]

Let $(\tilde{H}, \tilde{F}, *)$ be a FSH-space with IP: $\langle \tilde{x}, \tilde{y} \rangle = \sup\{\tilde{t} \in R: \tilde{F}(\tilde{x}, \tilde{y}, \tilde{t}) < 1\} \forall \tilde{x}, \tilde{y} \in \tilde{H}$ and let $\tilde{T} \in \tilde{B}(\tilde{H})$. Then \tilde{T} is fuzzy soft self-adjoint operator (FSSA-operator), if $\tilde{T} = \tilde{T}^*$ where \tilde{T}^* is fuzzy soft adjoint operator (FSA-operator) of \tilde{T} .

Definition 2.11:[13]

Let $(\tilde{H}, \tilde{F}, *)$ be a FSH-space with IP: $\langle \tilde{x}, \tilde{y} \rangle = \sup\{\tilde{t} \in R: \tilde{F}(\tilde{x}, \tilde{y}, \tilde{t}) < 1\} \forall \tilde{x}, \tilde{y} \in \tilde{H}$ and let $\tilde{T} \in \tilde{B}(\tilde{H})$. Then \tilde{T} is a FSN-operator if it commutes with its (fuzzy soft) adjoint. i.e. $\tilde{T}\tilde{T}^* = \tilde{T}^*\tilde{T}$.

Remark 2.12: [13]

It is obvious that every FSSA-operator is FSN-operator.

Theorem 2.13: [13]

If \tilde{T}_1 and \tilde{T}_2 are FSN-operators on $(\tilde{H}, \tilde{F}, *)$ with the property that either commutes with fuzzy adjoint of the other, then $\tilde{T}_1 + \tilde{T}_2$ and $\tilde{T}_1\tilde{T}_2$ are FSN-operator.

Theorem 2.14:[13]

Let $(\tilde{H}, \tilde{F}, *)$ be a FSH-space with IP: $\langle \tilde{x}, \tilde{y} \rangle = \sup\{\tilde{t} \in R: \tilde{F}(\tilde{x}, \tilde{y}, \tilde{t}) < 1\} \forall \tilde{x}, \tilde{y} \in \tilde{H}$ and let $\tilde{T} \in \tilde{B}(\tilde{H})$ be a FSN-operator iff $\|\tilde{T}^*\tilde{x}\| = \|\tilde{T}\tilde{x}\| \forall \tilde{x} \in \tilde{H}$.

Theorem 2.15:[13]

Let $\tilde{T} \in \tilde{B}(\tilde{H})$ be a FSN-operator on FSH-space. Then \tilde{T} is FSN-operator iff its real and imaginary parts commute.

Theorem 2.16:[13]

Let \tilde{T} be a FSN-operator on a finitedimensional FSH-space \tilde{H} and $\tilde{z} \in C(A)$. Then $\tilde{T} - \tilde{z}I$ is a FSN-operator.

Theorem 2.17:[13]

Let $(\tilde{H}, \tilde{F}, *)$ be a FSH-space with IP: $\langle \tilde{x}, \tilde{y} \rangle = \sup\{\tilde{t} \in R: \tilde{F}(\tilde{x}, \tilde{y}, \tilde{t}) < 1\} \forall \tilde{x}, \tilde{y} \in \tilde{H}$ and let $\tilde{T} \in \tilde{B}(\tilde{H})$. Then \tilde{T} is a FSU-operator if it satisfies $\tilde{T}\tilde{T}^* = I = \tilde{T}^*\tilde{T}$.

Note 2.18:[13]

Every FSU-operator is FSN-operator.

Theorem 2.19:[13]

If $\tilde{T} \in \tilde{B}(\tilde{H})$ is FSU-operator on \tilde{H} , then the following conditions are all equivalent to one another,

- (1) $\tilde{T}\tilde{T}^* = I$
- (2) $\langle \tilde{T}\tilde{x}, \tilde{T}\tilde{y} \rangle = \langle \tilde{x}, \tilde{y} \rangle \forall \tilde{x}, \tilde{y} \in \tilde{H}$
- (3) $\|\tilde{T}\tilde{x}\| = \|\tilde{x}\| \forall \tilde{x} \in \tilde{H}$

MAIN RESULTS

Definition 3.1:[Fuzzy Soft Hyponormal Operator]

Let $(\tilde{H}, \langle \cdot, \cdot \rangle)$ be a FSH-space and let $\tilde{T} \in \tilde{B}(\tilde{H})$. Then \tilde{T} is a FSHN-operator if $\tilde{T}^*\tilde{T} - \tilde{T}\tilde{T}^* \geq 0$ or $\tilde{T}\tilde{T}^* \leq \tilde{T}^*\tilde{T}$

Lemma 3.2:

Let $(\tilde{H}, \langle \cdot, \cdot \rangle)$ be a FSH-space and let $\tilde{T} \in \tilde{B}(\tilde{H})$. Then \tilde{T} is a FSHN-operator iff $\|\tilde{T}^*\tilde{x}\| \leq \|\tilde{T}\tilde{x}\| \forall \tilde{x} \in \tilde{H}$.

Proof:

Since $\tilde{T} \in \tilde{B}(\tilde{H})$ is a FHN-operator, then by the definition, $\tilde{T}^*\tilde{T} - \tilde{T}\tilde{T}^* \geq 0$.

$\Rightarrow \tilde{T}^*\tilde{T} \geq \tilde{T}\tilde{T}^*$





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It is enough to prove $\tilde{T}\tilde{T}^* \leq \tilde{T}^*\tilde{T}$
 Consider $\|\tilde{T}^*\tilde{x}\| \leq \|\tilde{T}\tilde{x}\|$, then

$$\begin{aligned} \|\tilde{T}^*\tilde{x}\| \leq \|\tilde{T}\tilde{x}\| &\Leftrightarrow \|\tilde{T}^*\tilde{x}\|^2 \leq \|\tilde{T}\tilde{x}\|^2 \\ &\Leftrightarrow \langle \tilde{T}^*\tilde{x}, \tilde{T}^*\tilde{x} \rangle \leq \langle \tilde{T}\tilde{x}, \tilde{T}\tilde{x} \rangle \\ &\Leftrightarrow \langle \tilde{T}\tilde{T}^*\tilde{x}, \tilde{x} \rangle \leq \langle \tilde{T}^*\tilde{T}\tilde{x}, \tilde{x} \rangle \\ &\Leftrightarrow \langle (\tilde{T}\tilde{T}^* - \tilde{T}^*\tilde{T})\tilde{x}, \tilde{x} \rangle \leq 0 \\ &\Leftrightarrow \tilde{T}\tilde{T}^* - \tilde{T}^*\tilde{T} \leq 0 \\ &\Leftrightarrow \tilde{T}\tilde{T}^* \leq \tilde{T}^*\tilde{T} \end{aligned}$$

Hence $\|\tilde{T}^*\tilde{x}\| \leq \|\tilde{T}\tilde{x}\| \Leftrightarrow \tilde{T}^*\tilde{T} - \tilde{T}\tilde{T}^* \geq 0$.

Theorem 3.3:

Let $(\tilde{H}, \langle, \rangle)$ be a FSH-space and let $\tilde{T} \in \tilde{B}(\tilde{H})$. Then \tilde{T} is a FSHN-operator and \tilde{S} be unitarily equivalent to \tilde{T} . Then \tilde{S} is a FSHN-operator.

Proof:

For \tilde{S} is unitarily equivalent to \tilde{T} , we have $\tilde{S} = \tilde{U}\tilde{T}\tilde{U}^*$, for some unitary operator \tilde{U} .

Implies that $\tilde{S}^2 = \tilde{U}\tilde{T}^2\tilde{U}^* \Rightarrow \|\tilde{S}^2\tilde{x}\| = \|(\tilde{U}\tilde{T}^2\tilde{U}^*)\tilde{x}\|$.

Consider $\|\tilde{S}^*\tilde{x}\|^2$. Then

$$\begin{aligned} \|\tilde{S}^*\tilde{x}\|^2 &= \langle \tilde{S}^*\tilde{x}, \tilde{S}^*\tilde{x} \rangle \\ &= \langle \tilde{S}\tilde{S}^*\tilde{x}, \tilde{x} \rangle \\ &= \langle (\tilde{U}\tilde{T}\tilde{U}^*)(\tilde{U}\tilde{T}\tilde{U}^*)^*\tilde{x}, \tilde{x} \rangle \\ &= \langle (\tilde{U}\tilde{T}\tilde{U}^*)(\tilde{U}\tilde{T}^*\tilde{U}^*)\tilde{x}, \tilde{x} \rangle \\ &= \langle (\tilde{U}\tilde{T}\tilde{T}^*\tilde{U}^*)\tilde{x}, \tilde{x} \rangle \\ &= \langle (\tilde{T}\tilde{T}^*\tilde{U}^*)\tilde{x}, \tilde{U}^*\tilde{x} \rangle \\ &\leq \langle (\tilde{T}^*\tilde{T}\tilde{U}^*)\tilde{x}, \tilde{U}^*\tilde{x} \rangle \\ &= \langle (\tilde{U}\tilde{T}^*\tilde{T}\tilde{U}^*)\tilde{x}, \tilde{x} \rangle \\ &= \langle (\tilde{U}\tilde{T}^*\tilde{U}^*)(\tilde{U}\tilde{T}\tilde{U}^*)\tilde{x}, \tilde{x} \rangle \\ &= \langle (\tilde{U}\tilde{T}\tilde{U}^*)(\tilde{U}\tilde{T}^*\tilde{U}^*)\tilde{x}, \tilde{x} \rangle \\ &= \langle \tilde{S}^*\tilde{S}\tilde{x}, \tilde{x} \rangle \\ &= \langle \tilde{S}\tilde{x}, \tilde{S}\tilde{x} \rangle \end{aligned}$$

$$\|\tilde{S}^*\tilde{x}\|^2 \leq \|\tilde{S}\tilde{x}\|^2$$

$$\|\tilde{S}^*\tilde{x}\| \leq \|\tilde{S}\tilde{x}\|$$

Hence \tilde{S} is a FSHN-operator.

Theorem 3.4:

Let $(\tilde{H}, \langle, \rangle)$ be a FSH-space and let $\tilde{T} \in \tilde{B}(\tilde{H})$. Let \tilde{T} and \tilde{T}^* be a FSHN-operator. Then \tilde{T} be a FSN-operator.

Proof:

Given \tilde{T} and \tilde{T}^* be a FSHN-operator. Then $\tilde{T}\tilde{T}^* \leq \tilde{T}^*\tilde{T}$ and $\tilde{T}^*(\tilde{T}^*)^* \leq (\tilde{T}^*)^*\tilde{T}^*$
 $\Rightarrow \tilde{T}^*\tilde{T} \leq \tilde{T}\tilde{T}^*$.

For $\tilde{x} \in \tilde{H}$, it is true that

$$\begin{aligned} \langle \tilde{T}\tilde{T}^*\tilde{x}, \tilde{x} \rangle &\leq \langle \tilde{T}^*\tilde{T}\tilde{x}, \tilde{x} \rangle \text{ and } \langle \tilde{T}^*\tilde{T}\tilde{x}, \tilde{x} \rangle \leq \langle \tilde{T}\tilde{T}^*\tilde{x}, \tilde{x} \rangle \text{ Then} \\ \langle \tilde{T}\tilde{T}^*\tilde{x}, \tilde{x} \rangle - \langle \tilde{T}^*\tilde{T}\tilde{x}, \tilde{x} \rangle &\leq 0 \text{ and } \langle \tilde{T}^*\tilde{T}\tilde{x}, \tilde{x} \rangle - \langle \tilde{T}\tilde{T}^*\tilde{x}, \tilde{x} \rangle \leq 0 \\ \langle -(\tilde{T}^*\tilde{T} - \tilde{T}\tilde{T}^*)\tilde{x}, \tilde{x} \rangle &\leq 0 \text{ and } \langle \tilde{T}^*\tilde{T}\tilde{x}, \tilde{x} \rangle - \langle \tilde{T}\tilde{T}^*\tilde{x}, \tilde{x} \rangle \leq 0 \\ \langle (\tilde{T}^*\tilde{T} - \tilde{T}\tilde{T}^*)\tilde{x}, \tilde{x} \rangle &\geq 0 \text{ and } \langle (\tilde{T}^*\tilde{T} - \tilde{T}\tilde{T}^*)\tilde{x}, \tilde{x} \rangle \leq 0 \\ &\Rightarrow \langle (\tilde{T}^*\tilde{T} - \tilde{T}\tilde{T}^*)\tilde{x}, \tilde{x} \rangle = 0 \\ &\Rightarrow (\tilde{T}^*\tilde{T} - \tilde{T}\tilde{T}^*)\tilde{x} = 0 \\ &\Rightarrow \tilde{T}^*\tilde{T} - \tilde{T}\tilde{T}^* = 0 \\ &\Rightarrow \tilde{T}^*\tilde{T} = \tilde{T}\tilde{T}^* \end{aligned}$$





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Thus, \tilde{T} is a FSN-operator.

Theorem 3.5:

Let $(\tilde{H}, \langle \cdot, \cdot \rangle)$ be a FSH-space and let \tilde{S} and $\tilde{T} \in \tilde{B}(\tilde{H})$ be FSHN-operators. If \tilde{S} and \tilde{T} are commute and $\tilde{T}^* \tilde{S} = \tilde{S} \tilde{T}^*$. Then $\tilde{S} + \tilde{T}$ and $\tilde{S} \tilde{T}$ are also a FSHN-operator.

Proof:

For every unit vector $\tilde{x} \in \tilde{H}$. We know that $\tilde{S} \in \tilde{B}(\tilde{H})$ be FSHN-operator, $\|\tilde{S}^2 \tilde{x}\| \leq \|\tilde{S} \tilde{x}\|^2$ i.e. $\tilde{S} \tilde{S}^* \leq \tilde{S}^* \tilde{S}$, and $\tilde{T} \in \tilde{B}(\tilde{H})$ be FSHN-operator, $\|\tilde{T}^2 \tilde{x}\| \leq \|\tilde{T} \tilde{x}\|^2$ i.e. $\tilde{T} \tilde{T}^* \leq \tilde{T}^* \tilde{T}$.

To prove that $\tilde{S} + \tilde{T}$ is a FPN-operator.

Consider $\|(\tilde{S} + \tilde{T})^* \tilde{x}\|^2$. Then

$$\begin{aligned} \|(\tilde{S} + \tilde{T})^* \tilde{x}\|^2 &= \langle (\tilde{S} + \tilde{T})^* \tilde{x}, (\tilde{S} + \tilde{T})^* \tilde{x} \rangle \\ &= \langle (\tilde{S} + \tilde{T}) (\tilde{S} + \tilde{T})^* \tilde{x}, \tilde{x} \rangle \\ &= \langle (\tilde{S} + \tilde{T}) (\tilde{S}^* + \tilde{T}^*) \tilde{x}, \tilde{x} \rangle \\ &= \langle (\tilde{S} \tilde{S}^* + \tilde{S} \tilde{T}^* + \tilde{T} \tilde{S}^* + \tilde{T} \tilde{T}^*) \tilde{x}, \tilde{x} \rangle \\ &\leq \langle (\tilde{S}^* \tilde{S} + \tilde{T}^* \tilde{S} + \tilde{S}^* \tilde{T} + \tilde{T}^* \tilde{T}) \tilde{x}, \tilde{x} \rangle \\ &\leq \langle (\tilde{S}^* (\tilde{S} + \tilde{T}) + \tilde{T}^* (\tilde{S} + \tilde{T})) \tilde{x}, \tilde{x} \rangle \\ &\leq \langle ((\tilde{S}^* + \tilde{T}^*) (\tilde{S} + \tilde{T})) \tilde{x}, \tilde{x} \rangle \\ &\leq \langle ((\tilde{S} + \tilde{T})^* (\tilde{S} + \tilde{T})) \tilde{x}, \tilde{x} \rangle \end{aligned}$$

$$\leq \langle (\tilde{S} + \tilde{T}) \tilde{x}, (\tilde{S} + \tilde{T}) \tilde{x} \rangle$$

$$\leq \|(\tilde{S} + \tilde{T}) \tilde{x}\|^2 \|\tilde{x}\|$$

$$\Rightarrow \|(\tilde{S} + \tilde{T})^* \tilde{x}\|^2 \leq \|(\tilde{S} + \tilde{T}) \tilde{x}\|^2$$

$$\Rightarrow \|(\tilde{S} + \tilde{T})^* \tilde{x}\| \leq \|(\tilde{S} + \tilde{T}) \tilde{x}\|$$

Therefore $\tilde{S} + \tilde{T}$ is a FSHN-operator.

To prove that $\tilde{S} \tilde{T}$ is a FSHN-operator.

Let $\tilde{x} \in \tilde{H}$. Then Consider $\|(\tilde{S} \tilde{T})^* \tilde{x}\|^2$. Then

$$\begin{aligned} \|(\tilde{S} \tilde{T})^* \tilde{x}\|^2 &= \langle (\tilde{S} \tilde{T})^* \tilde{x}, (\tilde{S} \tilde{T})^* \tilde{x} \rangle \\ &= \langle (\tilde{S} \tilde{T}) (\tilde{S} \tilde{T})^* \tilde{x}, \tilde{x} \rangle \\ &= \langle (\tilde{S} \tilde{T}) (\tilde{T}^* \tilde{S}^*) \tilde{x}, \tilde{x} \rangle \\ &= \langle (\tilde{T} \tilde{T}^*) \tilde{S}^* \tilde{x}, \tilde{S}^* \tilde{x} \rangle \\ &\leq \langle (\tilde{T}^* \tilde{T}) \tilde{S}^* \tilde{x}, \tilde{S}^* \tilde{x} \rangle \end{aligned}$$

$$\leq \langle \tilde{T} \tilde{S}^* \tilde{x}, \tilde{T} \tilde{S}^* \tilde{x} \rangle$$

$$\leq \langle \tilde{S}^* \tilde{T} \tilde{x}, \tilde{S}^* \tilde{T} \tilde{x} \rangle$$

$$\leq \langle (\tilde{T}^* \tilde{S}^*) (\tilde{S} \tilde{T}) \tilde{x}, \tilde{x} \rangle$$

$$\leq \langle (\tilde{S} \tilde{T})^* (\tilde{S} \tilde{T}) \tilde{x}, \tilde{x} \rangle$$

$$\leq \langle (\tilde{S} \tilde{T}) \tilde{x}, (\tilde{S} \tilde{T}) \tilde{x} \rangle$$

$$\Rightarrow \|(\tilde{S} \tilde{T})^* \tilde{x}\|^2 \leq \|(\tilde{S} \tilde{T}) \tilde{x}\|^2$$

$$\Rightarrow \|(\tilde{S} \tilde{T})^* \tilde{x}\| \leq \|(\tilde{S} \tilde{T}) \tilde{x}\|$$

Therefore $\tilde{S} \tilde{T}$ is a FSHN-operator.

Theorem 3.6:

Let $(\tilde{H}, \langle \cdot, \cdot \rangle)$ be a FSH-space and let \tilde{S} and $\tilde{T} \in \tilde{B}(\tilde{H})$ be a FSHN-operator on \tilde{H} . Then $\|(\tilde{T}^* - \tilde{z} \tilde{I}) \tilde{x}\| \leq \|(\tilde{T} - \tilde{z} \tilde{I}) \tilde{x}\| \forall \tilde{x} \in \tilde{H}$, i.e. $(\tilde{T} - \tilde{z} \tilde{I})$ is FSHN-operator.

Proof:

Given \tilde{T} is a FSHN-operator on \tilde{H} .





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Let $\|(\tilde{T} - \tilde{z}\tilde{T})\tilde{x}\|^2 = \langle (\tilde{T} - \tilde{z}\tilde{T})\tilde{x}, (\tilde{T} - \tilde{z}\tilde{T})\tilde{x} \rangle$. Then

$$\begin{aligned} \|(\tilde{T} - \tilde{z}\tilde{T})\tilde{x}\|^2 &= \langle (\tilde{T} - \tilde{z}\tilde{T})\tilde{x}, (\tilde{T} - \tilde{z}\tilde{T})\tilde{x} \rangle \\ &= \langle (\tilde{T} - \tilde{z}\tilde{T})^* (\tilde{T} - \tilde{z}\tilde{T})\tilde{x}, \tilde{x} \rangle \\ &\geq \langle (\tilde{T} - \tilde{z}\tilde{T})(\tilde{T} - \tilde{z}\tilde{T})^* \tilde{x}, \tilde{x} \rangle \\ &\quad \text{[since, by definition of FSHN-operator]} \\ &\geq \langle (\tilde{T} - \tilde{z}\tilde{T})^* \tilde{x}, (\tilde{T} - \tilde{z}\tilde{T})\tilde{x} \rangle \end{aligned}$$

$$\|(\tilde{T} - \tilde{z}\tilde{T})\tilde{x}\|^2 \geq \|(\tilde{T} - \tilde{z}\tilde{T})^* \tilde{x}\|^2$$

$$\|(\tilde{T} - \tilde{z}\tilde{T})\tilde{x}\| \geq \|(\tilde{T} - \tilde{z}\tilde{T})^* \tilde{x}\|$$

i.e. $\|(\tilde{T} - \tilde{z}\tilde{T})^* \tilde{x}\| \leq \|(\tilde{T} - \tilde{z}\tilde{T})\tilde{x}\|$

Hence $\tilde{T} - \tilde{z}\tilde{T}$ is FSHN-operator.

Theorem 3.7

Let $\tilde{T} \in \tilde{B}(\tilde{H})$ be a FSHN-operator on a FSH-space \tilde{H} . Then $\tilde{T}\tilde{x} = \tilde{z}\tilde{x} \Rightarrow \tilde{T}^*\tilde{x} = \tilde{z}\tilde{x}$

Proof

Let \tilde{x} be an eigen vector of \tilde{T} corresponding to the eigen value \tilde{z} . i.e $\tilde{T}\tilde{x} = \tilde{z}\tilde{x}$.

Now, $\langle \tilde{T}\tilde{x}, \tilde{T}\tilde{x} \rangle = \langle \tilde{T}^*\tilde{T}\tilde{x}, \tilde{x} \rangle$

$$\geq \langle \tilde{T}\tilde{T}^*\tilde{x}, \tilde{x} \rangle \text{ [Since } \tilde{T} \text{ is FSHN-operator]}$$

$$\langle \tilde{T}\tilde{x}, \tilde{T}\tilde{x} \rangle \geq \langle \tilde{T}^*\tilde{x}, \tilde{T}^*\tilde{x} \rangle \tag{3.1}$$

Since by the Theorem (3.6), $\tilde{T} - \tilde{z}\tilde{T}$ is a FHN-operator, therefore for each $\tilde{x} \in \tilde{H}$, equation (3.1) becomes,

$$\langle (\tilde{T} - \tilde{z}\tilde{T})\tilde{x}, (\tilde{T} - \tilde{z}\tilde{T})\tilde{x} \rangle \geq \langle (\tilde{T} - \tilde{z}\tilde{T})^* \tilde{x}, (\tilde{T} - \tilde{z}\tilde{T})^* \tilde{x} \rangle$$

Since $\tilde{T}\tilde{x} = \tilde{z}\tilde{x}$, we have

$$\begin{aligned} \tilde{T}\tilde{x} &= \tilde{z}\tilde{x} \\ \Rightarrow \tilde{T}\tilde{x} - \tilde{z}\tilde{T}\tilde{x} &= 0 \\ \Rightarrow (\tilde{T} - \tilde{z}\tilde{T})\tilde{x} &= 0 \end{aligned}$$

$$\Rightarrow (\tilde{T} - \tilde{z}\tilde{T}) = 0 \tag{3.2}$$

Then, $\langle (\tilde{T} - \tilde{z}\tilde{T})\tilde{x}, (\tilde{T} - \tilde{z}\tilde{T})\tilde{x} \rangle = 0 \quad \forall \tilde{x} \in \tilde{H}$,

$$\Rightarrow \langle (\tilde{T} - \tilde{z}\tilde{T})^* \tilde{x}, (\tilde{T} - \tilde{z}\tilde{T})^* \tilde{x} \rangle = 0 \quad \forall \tilde{x} \in \tilde{H}, \tag{3.3}$$

From $(\tilde{T} - \tilde{z}\tilde{T})^* \tilde{x} = 0$, Then for each $\tilde{x} \in \tilde{H}$,

$$\Rightarrow (\tilde{T} - \tilde{z}\tilde{T})^* \tilde{x} = 0$$

$$\Rightarrow (\tilde{T}^* - \tilde{z}\tilde{T}^*) \tilde{x} = 0$$

$$\Rightarrow \tilde{T}^*\tilde{x} - \tilde{z}\tilde{T}^*\tilde{x} = 0$$

$$\Rightarrow \tilde{T}^*\tilde{x} = \tilde{z}\tilde{x}$$

\tilde{x} is an eigen vector of \tilde{T}^* corresponding to eigen value \tilde{z}

Theorem 3.8

Let $\tilde{T} \in \tilde{B}(\tilde{H})$ be a FSHN-operator with $\tilde{T}\tilde{x}_1 = \tilde{z}_1\tilde{x}_1$, $\tilde{T}\tilde{x}_2 = \tilde{z}_2\tilde{x}_2$ and $\tilde{z}_1 \neq \tilde{z}_2$. Then $\langle \tilde{x}_1, \tilde{x}_2 \rangle = 0$.

Proof

Since $\tilde{T} \in \tilde{B}(\tilde{H})$ is a FSHN-operator with $\tilde{T}\tilde{x}_1 = \tilde{z}_1\tilde{x}_1$, $\tilde{T}\tilde{x}_2 = \tilde{z}_2\tilde{x}_2$ and $\tilde{z}_1 \neq \tilde{z}_2$, then by Theorem (3.7),

$$\tilde{T}^*\tilde{x}_1 = \tilde{z}_1\tilde{x}_1, \tilde{T}^*\tilde{x}_2 = \tilde{z}_2\tilde{x}_2.$$

Consider $\tilde{z}_1 \langle \tilde{x}_1, \tilde{x}_2 \rangle$, then

$$\tilde{z}_1 \langle \tilde{x}_1, \tilde{x}_2 \rangle = \langle \tilde{z}_1\tilde{x}_1, \tilde{x}_2 \rangle$$

$$= \langle \tilde{T}\tilde{x}_1, \tilde{x}_2 \rangle$$

$$= \langle \tilde{x}_1, \tilde{T}^*\tilde{x}_2 \rangle$$





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$$= \langle \tilde{x}_1, \tilde{z}_2 \tilde{x}_2 \rangle$$

$$= \langle \tilde{z}_2 \tilde{x}_1, \tilde{x}_2 \rangle$$

$$= \tilde{z}_2 \langle \tilde{x}_1, \tilde{x}_2 \rangle$$

Hence, if $\tilde{z}_1 \neq \tilde{z}_2$, then $\langle \tilde{x}_1, \tilde{x}_2 \rangle = 0$. i.e. $\tilde{x}_1 \perp \tilde{x}_2$

CONCLUSION

From this paper, the concept of Fuzzy Soft Hyponormal operators (FSHN-operators) in Fuzzy Soft Hilbert spaces (FSH-spaces) has been constructed from family of operators. Some elementary properties of these operators are discussed. Moreover, some relations between FSHN-operators and Fuzzy Soft Normal operators (FSN-operators) in FSH-spaces are obtained from Fuzzy Soft Self-Adjoint (FSSA), Fuzzy Soft Unitary (FSU), invertible and unitary equivalent.

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Blockchain Structural Dynamics: A Thorough Exploration of Architectural Configurations, Design Methodologies, Consensus Protocols, and Forking

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ABSTRACT

The blocks in a blockchain are linked together in a systematic chain, and they record user transactions and other data. Blockchain's main purpose is to facilitate decentralised, peer-to-peer transactions. This innovation was developed at first to facilitate Bitcoin, the world-famous cryptocurrency. With this technology, people on a network may conduct transactions with one another in a way that is both private and visible, thanks to the use of cryptography. It's a game-changing innovation that's gaining traction thanks to digital currencies like Bitcoin (BTC) and Ether (ETH). The transaction is recorded on an immutable distributed ledger and trust is established amid previously unknown peers. The centralization of any organization's financial records makes them vulnerable to hacking and manipulation for the sake of wealth and influence. The decentralized structure of blockchain ensures that all transaction records are immune to tampering and fraud. Blockchain has great potential for improving the online transaction system, but it also has a number of security flaws. With any luck, this paper's overview of blockchain methodology, its applications, and security can help enlighten blockchain devotees and academics.

Keywords: Blockchain, Web3.0, Genesis Block, Distributed ledger (DLT), Bitcoin (BTC), Ether (ETH), Peer – to – Peer Network, Mining, Immutability, Smart Contract, Consensus, Transaction, Transaction Pool (Mem Pool), Wallet, Trust less, Public Blockchain, Private Blockchain, Consortium Blockchain, Hash Function, Hashrate, Forks, DApps, Double Spending, PoW (Proof of Work), PoS (Proof of Stack), PBFT (Practical Byzantine Fault Tolerance), Gas Points, Nonce



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INTRODUCTION

Without the availability of information, the business world cannot function. The sooner it is received, the sooner it will be accurate, and the sooner it will be of higher quality. Because it delivers data that is immediate, shareable, and entirely transparent, blockchain is a useful instrument for giving information. This data is recorded on an immutable ledger, and the only users who are able to read it are those who have been granted permission to do so by the administrators of the network. Because all of the participants have the same understanding of the truth, you are able to observe all of the facts of a transaction from the very beginning to the very conclusion and everything in between. Not only does this provide you with favourable perceptions, but it also provides you with more opportunities and efficiency.

Benefits

- Users are rewarded for their mining efforts so that the network is secure.
- The incentive payments received by miners give them a disposable income that can be utilized for anything they see fit.
- People are also more likely to put money into cryptocurrencies, which contributes to their widespread adoption.

Drawbacks

- Payouts are not uniform and change from one project to the next.
- The number of awards every block and when those incentives are distributed varies between projects.
- Higher expenditures are inevitable because specialized hardware (CPU, GPU, ASIC) is needed for mining.
- The high cost of electricity used in mining typically results in a loss for miners rather than a profit.

BLOCKCHAIN TECHNOLOGY

One of the first blocks on a blockchain is called the genesis block, and it serves as the basis from which all subsequent blocks are constructed. In most cases, it is created or hardcoded into the source code of the blockchain. It is distinguished by its unique qualities as the first block, as it does not have a predecessor. A timestamp, a nonce, and a special message could be comprised of the data contained within. Because it marks the beginning of the blockchain's existence, the genesis block is significant from a symbolic standpoint. Additionally, the qualities of the genesis block establish the tone for the entire chain, influencing aspects such as immutability, security, and cultural significance. The genesis block of Bitcoin, which was mined by Satoshi Nakamoto in 2009, is a remarkable example. It contains a transaction on coinbase that refers to a headline from The Times newspaper. (Please have glance at figure 1 & 2 for better understanding.) Due to the fact that it is decentralized and cannot be altered, blockchain technology makes the process of recording business transactions and monitoring corporate assets much simpler. In addition to tangible assets (such a house, a car, cash, or land), there are also intangible assets (including intellectual property, patents, copyrights, and branding) that exist. Goodwill is an example of an intangible asset. It is possible to document and trade virtually anything on a blockchain network, which will reduce the amount of ambiguity and save money for people who are currently participating.

Terminology in Blockchain

Begin to think of a blockchain as a computer - all you have to do now is adapt the terminology and comprehend that there are thousands of computers running across the world.

Peer-to-Peer Network

Often abbreviated to "P2P," a peer-to-peer network (P2N) is a decentralized network communications paradigm in which a set of devices (nodes) store and distribute files collectively, with each node acting as an independent "peer."



**Maitri Hingu and Kamlendu Pandey****Nodes**

The blockchain is not a central server but rather a distributed network of computers around the world that work together to verify transactions and store data. Nodes and validators are the individual computers that are rewarded for their participation in the network with tokens that are unique to the network.

Identity

An individual's private key is used to identify them throughout the blockchain. Due to the fact that this pertains to the vast majority of transactions, it is of the utmost importance to be aware that the person sending it is given permission to do so. For the purpose of ensuring that this conclusion occurs, elliptic cryptography is being utilised. One of the components of the key pair that is specific to each user is a private key, while the other component is a public key. Each and every transaction is digitally signed using the user's private key, which is something that the user and only the user can access using their private key. After the signature has been created, anyone can verify this signature by simply glancing at the user's public key; they do not need to be aware of the user's private key in order to do so.

State

Data are known as states. The blockchain functions as a data storage system, similar to how a computer saves documents like Word, Excel, and PowerPoint. The total amount of information stored in a blockchain is referred to as the blockchain's "state." Each node in the network has access to this information since it serves as a standard layer of state. That's one key way in which a blockchain stands apart from the web: Everyone has access to the same global state, much like you have access to all the files on your computer.

Fungible Token

Tokens in a fungible cryptocurrency are digital coins or tokens that share all the characteristics of traditional fungible assets. This means that these crypto tokens must be fungible, divisible, and have a fixed market price. Tokens that can be easily split into smaller parts and exchanged between users shouldn't be hard to value or use in a cryptocurrency trading environment. Fungible coins can be bought and sold at any exchange or on any coin price aggregator website. Example: Bitcoin, Ethereum, and Dogecoin.

Non-Fungible Token

The information contained in an NFT is irreversible and indivisible. As a result, many individuals compare NFTs to intellectual property (IP) rights. In contrast to fungible assets, NFTs are always created on a smart contract blockchain, such as Ethereum. While fungible crypto can be built on top of an existing blockchain, many fungible tokens and currencies are blockchain-native. Example: Litecoin.

Smart contracts

Computer Programs are known as smart contracts in blockchain. The data included on a blockchain can be altered in the same ways that files on your computer can be opened, modified, and deleted. This is accomplished mostly through the use of several programs on your own computer, such as a text editor or an image processing program. In the blockchain, the name most frequently given to computer programs is "smart contracts." There are blockchains that can work without smart contracts, however blockchains that have the functionality of smart contracts can typically accommodate considerably more complex use cases.

Wallets

Wallets are sometimes referred to as accessibility points and identity managers. Transactions are sent through a wallet, which is a programme that maintains a user's private key and can function as an access point to the blockchain. This allows transactions to be submitted directly from the wallet. The vast majority of user transactions are sent through the usage of a wallet. Transactions can be sent through the usage of wallets. The user does not have to physically insert and manage the private key while using a wallet, which is one of the benefits of utilising such a



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device. Wallets are becoming increasingly advantageous. Wallets are available in a broad variety of formats, including software, hardware, and even paper-based variants. Other types include electronic wallets.

Transactions

User actions are known as transactions. It is necessary to broadcast a transaction to the network in order to put into action a feature of a piece of software (also known as a method of a smart contract). To the same extent that apps running on the internet are susceptible to spamming, so are blockchain networks. The majority of the time, this takes the form of an attacker flooding the network with an infinite number of transaction requests, so exceeding its capacity. In most cases, a transaction cost, also known as Gas, is attached to each and every transaction. This is done in an effort to prevent the occurrence of the scenario described above. This is a protection measure to prevent spamming of the network. Blockchain is a distributed immutable database that operates in a peer-to-peer connected network. Because of its immutability, it is trustworthy among the nodes inside the network [1], [2]. Using cryptographic proof, blockchain technology has the potential to give trustworthiness [1], [2]. Directly sending and receiving money or any other digital item is possible between the sender and the receiver, without the requirement for a third party to be involved [1], [2]. Users can be protected from the attack of double spending, whether they do so consciously or unknowingly, thanks to blockchain technology. All transactions are stored in chronological order, as stated in references [1], [2]. They proposed a peer-to-peer network that would make use of proof-of-work in order to record a public history of transactions in [1], [2]. Due to the fact that it would be computationally impractical for an adversary to alter this history, it would be impossible for them to do so if honest nodes held the majority of the CPU power [1], [2]. There is a problem with the fact that the receiver is unable to verify that one of the owners had not engaged in double spending [1], [2]. It is necessary for us to have a means by which the receiver can be told that the previous owners did not sign any transactions that took place in the past. Since the oldest transaction is the one that matters, we do not care about any subsequent attempts to double-spend because the earliest transaction is the one that matters. Awareness of all of the transactions that have taken place is the only way to confirm that there was no transaction. This is the only method that may be used. In order to accomplish this without the assistance of a reliable third party, the transactions need to be made known to the general public. Furthermore, we seek a system that enables participants to achieve a consensus on a single history of the order in which they were received at the same time. At the time of each transaction, the payee is obliged to give evidence that the majority of nodes concurred that the transaction was the first received. This proof must be presented. In [1]–[3], they have steps to run the network are as follows:

Step 1: New transactions are broadcast to all nodes

Step 2: Each node collects new transactions into a block

Step 3: Each node works on finding a difficult proof-of-work for its block

Step 4: When a node finds a proof-of-work, it broadcasts the block to all nodes

Step 5: Nodes accept the block only if all transactions in it are valid and not already spent

Step 6: Nodes express their acceptance of the block by working on creating the next block in the chain, using the hash of the accepted block as the previous hash (Refer figure 3 for pictorial demonstration of above steps.) When a new block is introduced to the chain, the consensus protocol has the responsibility of ensuring that all of the nodes in the Blockchain agree with the same version of the events. Consensus, collaboration, cooperation, equal rights for all nodes, and mandated involvement from all nodes are all aims of the Blockchain consensus protocol. Additionally, the protocol requires that all nodes involve themselves. Because of this, the objective of a consensus algorithm is to arrive at a solution that is advantageous to all of the participants in the network.

PoW (Proof of Work)

Proof-of-work consensus is utilized by the majority of cryptocurrencies. Algorithms are responsible for validating transactions and building blocks on the blockchain. The Proof of Work (PoW) idea established by Cynthia Dwork and Moni Naor in 1993 was utilized in the Bitcoin paper written by Satoshi Nakamoto in 2008. It is a solution that is difficult to locate yet simple to verify. Bitcoin, Ethereum, and Litecoin all use Proof-of-Work. How it works?

- The new block is validated and posted to the blockchain.



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- The longest block chain will receive the block.
- Miners solve a tough mathematical challenge to add the block to the network, ergo Proof-of-Work.
- Time complicates the mathematical difficulty.

PoS (Proof of Stake)

PoW alternative that is used the most frequently. Consensus on Ethereum is now based on PoS. Validators invest part of their coins in this consensus process rather than purchasing expensive technology in order to find a solution to a difficult problem. Following that, each and every validator will validate the blocks. In order to determine whether or not a block can be added to the chain, validators will gamble on it. The amount of compensation that validators receive is proportional to the amount of money they wager on the Blockchain's actual blocks. It is determined by the validator's economic stake in the network which validator will be chosen to generate a new block. Incentives for validators to come to an agreement are provided by PoS.

PBFT (Practical Byzantine Fault Tolerance)

A consensus technique known as Practical Byzantine Fault Tolerance was initially presented by Barbara Liskov and Miguel Castro in the latter part of the 1990s. The PBFT algorithm was designed to handle asynchronous systems, which have no maximum limit on response time. It reduces the amount of overhead. The existing Byzantine Fault Tolerance methods were improved in a number of ways as a result of this. In the event that certain nodes in a distributed network fail to respond or respond with erroneous information, Byzantine Fault Tolerance (BFT) makes it possible for the network to establish a consensus. In order to reduce the influence of defective nodes and prevent system breakdowns, BFT processes make use of communal decision making, which includes both right and faulty nodes. The BFT was inspired by the Byzantine Generals' Problem. A list of blocks, which can be thought of as a public ledger, is where all of the transactions that have been committed are stored [15]. Blockchain technology makes use of consensus methods in order to maintain data consistency over a distributed network [15] with great success. A public blockchain is characterized by the fact that records are maintained on a large number of participants, making it extremely difficult to manipulate transactions on such a blockchain [15]. A comprehensive analysis is conducted in this paper [16] to assess the effectiveness of the consensus algorithms utilized by the Ethereum and Hyperledger Fabric private blockchain platforms. The technology that is fundamental to the cryptocurrency system that bitcoin represents is referred to as blockchain technology [16]. In this paper, the performance of consensus algorithms in private blockchains is analyzed, with a particular focus on the consensus layer [16].

The Proof-of-Work (PoW) protocol of Ethereum is routinely outperformed by the Proof-of-Facility (PBFT) protocol of Hyperledger Fabric in terms of latency and throughput of transactions. There are a number of significant supporting technologies, including peer-to-peer networks, asymmetric encryption, distributed data storage, consensus methods, and smart contracts [16]. First and foremost, we must resolve the various security concerns that have been raised by the widespread adoption of blockchain networks, particularly private blockchain networks, which are frequently adopted by businesses and other large organizations [17]. Blockchain is a distributed ledger that runs on a decentralized, peer-to-peer network. Despite a set of people having control over the hybrid blockchain, all transactions remain encrypted [17]. Any attempt to modify a data block will result in a new hash value being generated [17]. In blockchain technology, hashing a block consumes significant processing time [17]. An efficient and low-cost blockchain network would be the result of efforts to design a better consensus algorithm [17]. Hyperledger Fabric, Quorum, Ethereum, MultiChain, and R3 Corda were the five primary systems mentioned in order to compile and highlight the distinctions between them in one study [18].ed by distributed architectures that divide jobs or workloads among peers without the use of a reliable third party. The miners are in charge of determining if the sender and receiver successfully delivered the message [8]. They utilize a static game model to show how secure their incentive mechanism is. They suggest a safe method of validating transactions that is used by Bitcoin's miners. The security of their incentive system is ensured by a pricing method that is suggested [8]. There is a consistent belief across nodes that the chain with the longest length is the correct one, and they will continue to work towards extending it [1]–[3]. In the event that two nodes concurrently broadcast distinct versions of the subsequent block, it is



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possible for certain nodes to receive either one or the other version first [1]–[3]. In such a scenario, they focus their efforts on the first branch that they have been given, while preserving the other branch in the event that it becomes longer [1]–[3]. When the next proof-of-work is discovered, the tie will be broken, and one of the branches will become longer. The nodes that were working on the other branch will then move to the longer branch [1]–[3]. Nodes have the ability to quit and rejoin the network at their own discretion, and they are able to accept the proof-of-work chain as evidence of what occurred while they were absent [1], [2]. By utilising their central processing unit (CPU) power, they cast their vote, indicating their approval of legitimate blocks by trying to extend them, while simultaneously rejecting invalid blocks [1], [2]. Using a peer-to-peer distributed timestamp server, they suggest a solution to the double-spending problem in [1], [2]. This system is intended to generate computational verification of the chronological sequence of transactions. The implementation of the proof-of-work is carried out by increasing a nonce within the block until a value is discovered that provides the block's hash with the necessary zero bits [1], [2]. A decentralized ledger or data structure is referred to as blockchain. Each block is built on top of the one before it, and the latter's nonce and signature are used as a key to enter the block. Miners can easily estimate a random string or nonce in order to tamper with a block in a Public Blockchain just by knowing the signature [4]. It is difficult to tamper with the details of the transactions or events once they have been fed into the Blockchain [4]. Bitcoin was conceived as a way to create a safe currency with no centralized authority. The financial technology (FinTech) industry regards bitcoin blockchain technologies, also known as distributed-ledger technology, as having a lot of potential (DLT) [5].

Advances in blockchain protocol development are bringing us closer to realizing goals that only a few years ago appeared impossible. The miner must solve this puzzle in order to construct a block, which consumes both operational and capital resources [5]. Due to the difficulty of setting the parameter, Network coded-distributed storage is not trivially applicable to blockchain [6]. To solve the bloating issue, they propose network coded-based distributed storage as the storage structure for blockchain. Because the parameter is challenging to set, a trivial application of NC-DS to blockchain is challenging [6]. One can explore previous blockchain transactions and observe all transactions connected to a specific public key once it has been paired with a person's identification [7]. They suggest a pricing strategy for the secure Bitcoin system to protect against selfish user behavior and prevent collusion assaults, as well as a secure validation method carried out by the miners in the Bitcoin system rather than a reliable third party [8]. Peer-to-peer (P2P) applications are characterized, Through access to any node in the dispersed network, users can confirm and trace the previous records [9]. A similar blockchain-based approach was put forth to securely disseminate sensitive data in a decentralized fashion [9]. Both the business world and the academic community have given cryptocurrency a lot of attention [9]. As long as the proportion of flawed nodes in the Unique Node List is less than 20%, the ledger will continue to be accurate [9].

There are many different industries that are beginning to adopt blockchain technology or are considering implementing it in order to facilitate their operations. The goal of these industries is to get a competitive edge by streamlining procedures, boosting security and data sharing, increasing productivity, and cutting costs [10]. By establishing new advanced features for the business and industrial world, blockchain technology enables new possibilities [10]. It serves as the primary facilitator of the Internet of Transactions, which is essential for the functionality of a wide variety of industrial applications. Specific open protocols and standards that have been developed by individuals are incorporated into Hyperledger [10]. The applications that are emerging include those in the fields of finance, energy, logistics, healthcare, and manufacturing [10]. Among the major enablers for the utilization of blockchain technology in these applications, the rise of digital identities, distributed security, smart contracts, and micro-metering are among the most important drivers [10]. A machine learning method is provided by them for the purpose of identifying intelligent Ponzi activities [11]. It has been suggested that blockchain technology is a disruptive technology that will bring about changes in a variety of different industries [11]. In order to develop an efficient model for detecting smart Ponzi schemes without the need for source code, it is necessary for them to have a sufficient number of smart contracts that contain labels and features that are effective and can be obtained without the need for source code [11]. Using the etherscan.io platform, they gathered all of the open source code smart contracts that were created prior to September 7, 2017, and then personally examined them to determine whether or not they were Ponzi scheme contracts [11]. The goal of this work was to detect sophisticated Ponzi



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schemes utilizing bytecodes, utilizing machine learning and data mining approaches [11]. Upon careful observation, it is important to note that the properties of the code are extracted without the source code [11]. The proposed model can be applied to any contract at the moment of its inception [11]. Concerning the trust crisis conundrum, dealing with reliable third parties can be expensive or involve security hazards [12]. They offer a taxonomy on the subject of blockchain smart contract security verification [12]. Programming correctness and formal verification are two subcategories of the correctness verification component [12]. They go over how to create trustworthy smart contracts from the perspectives of formal verification and programming correctness [12]. Future study will focus on developing programming standards for smart contracts, creating a set of development procedures for smart contracts, and raising programmers' security awareness [12]. Through a comparative survey study, the blockchain's potential uses, advantages, and drawbacks are discussed [13]. Blockchain, in contrast to conventional systems, enables direct peer-to-peer transfers of digital assets [13]. Blockchain can be used to promote secure and privacy-maintained consumption monitoring and energy trade in smart grids with bidirectional communication flow [13]. A scalability issue with Bitcoin can be attributed to the limited size and frequency of the blocks as well as the volume of transactions the network can handle [13]. Takeaways and Reflections This section has covered some of the more fundamental problems that may arise when working with blockchain technology, such as the ambiguous terminology that is still used by some regulatory agencies [14]. Based on the findings of numerous investigations, this article analyses the prevalent security assaults on blockchain technologies and their vulnerabilities [14]. The liveness attack, which lengthens the time it takes for a transaction to be confirmed, the double-spending attack, which creates duplicate funds, and the private Key security assault are all dealt with [14].

CURRENT RESEARCH IN BLOCKCHAIN**Blockchain Consensus Algorithms**

In essence, Blockchain is a distributed ledger that is immutable, private, secure, and transparent. It also functions without the need for a central authority to oversee its operations. Despite the fact that there is no centralized authority that verifies the authenticity of the transactions that take place on the Blockchain, each and every one of them is accepted at face value. It is possible to accomplish this thanks to the consensus process, which is a key component of any blockchain. In a Blockchain network, it is necessary for all of the nodes to reach a consensus over the current state of the distributed ledger. This process is referred to as a consensus algorithm. Consensus methods are required in order to ensure that the Blockchain network operates in a dependable manner and to facilitate the establishment of trust between peers who were not previously acquainted with one another in a distributed computing environment. In terms of consensus procedures or fundamental money, each framework is a little bit unique [18]. Using data collected from published experiments, they evaluated the structures according to a number of parameters [18]. Latest versions of these platforms will be implemented, and they will be compared experimentally using various benchmarking tools. Major private blockchain frameworks and their features are outlined [18]. They acknowledge the following restrictions but nonetheless find our comparative analysis to be realistic [18]. Without completing a thorough study, the offered analysis can be utilized to select 2 frameworks for testing in their respective settings/environments [18]. They did a series of experiments to back up their theoretical model and found that it accurately predicted transaction latencies on average [19]. In this research, they provide a theoretical analysis approach for investigating Fabric's blockchain system's latency performance. They ran a battery of studies to back up the accuracy of these theoretical models [19]. The outcomes demonstrated the model's ability to accurately forecast the typical delay of a transaction. As a new technology, blockchain has been heralded for its potential to boost numerous industries' credibility, trustworthiness, and safety [19]. The research team led by Thakkar et al. (2018) tested Fabric V1.0 extensively to determine its performance [19]. Theoretical modelling determined the typical delay in reaching a PBFT consensus and identified some possible bottlenecks in performance [19].

Blockchain Security

A comprehensive risk management solution for blockchain networks, blockchain security comprises assurance services, cybersecurity guidelines, and best - practice to reduce the likelihood of fraud and cyberattacks. Due to their foundation in consensus, cryptography, and decentralization, the data structures proposed by blockchain technology



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inherently possess high levels of security. Information is nearly impossible to alter as it is added to the network because of the interconnectivity of its constituent blocks. Each transaction in a block is also verified and accepted by a consensus mechanism (approved users), ensuring that they are all legitimate and accurate. There is no single point of failure and no way for an individual to alter past transactions.

Private Blockchains

In order to participate in a private blockchain network, users must first be invited to join. Either the network's central administrator or initiator, or a predetermined set of rules, is responsible for validating users. Private blockchains are often implemented as permissioned networks in businesses. Permissioned networks restrict both the number of users and the types of transactions each user is allowed to make. Either an invitation or permission is required for members to join. A "Proof-of- Authority" (PoA) consensus mechanism is commonplace in private blockchains, which are often used in internal, business-secure contexts to handle activities like access, authentication, and record keeping. In most cases, the details of a transaction will remain confidential.

Public Blockchains

Blockchains that are accessible to the public, promotes openness and trustworthiness. Since the software is open-source and freely accessible to the public, anyone can take part in "decentralized" transaction consensus and validate network transactions (e.g., Bitcoin and Ethereum). Public blockchain networks are distinguished by its core feature, decentralization, achieved through crypto-economics, which is designed to guarantee collaboration across the distributed network. As a result, there is no single point of failure in the network's infrastructure or the underlying software in a public blockchain. The degree to which a blockchain is decentralized is contingent on factors such as the rules by which it is governed, the security of its cryptographic "private keys," and the incentives it offers its participants. Think about "data mining," wherein users earn cryptocurrency by verifying transactions. This incentive encourages others to join the network and help verify transactions. Who writes the code, who may participate in the consensus mechanism, and who has access to the community governance activities that keep the network running are all aspects of governance that need to be considered. Proof-of-Work (PoW) and Proof-of-Stake (PoS) are the two most used consensus mechanisms for public blockchains (PoS). There is a major distinction between public and private blockchains in terms of who can join and validate transactions.

Consortium Blockchains

In any case, there's a third possibility worth considering: consortium blockchains. Consortium blockchains are blockchain networks in which all of the nodes have been vetted and approved by a central authority. This "semi-permissioned" method permits some degree of control over a dispersed or partially decentralized network. Coincidentally, consortium blockchains allow for the privacy of transaction data.

The consortium blockchain can use Proof-of-Work (PoW), Proof-of-Authority (PoA), or Proof-of-Stake to obtain consensus (PoS). And there are more options, such as delegated proof-of-stake. Consortium blockchains work best in environments with a high degree of trust, such as in financial transactions, supply chain management, or the Internet of Things (IoT). Blockchain systems are extremely good at avoiding objective information fraud, such as loan application fraud, because the fake information is based on facts which will not match with existing data on blockchain [20].

Blockchain Rewards and Earnings

Miners receive block rewards for transaction approval. Mining a block yields it. Cryptocurrencies mine new currency and verify transactions.

Block rewards have two parts;

Subsidy: It's the main reward. New coins created.



**Maitri Hingu and Kamlendu Pandey****Fees**

Block transactions also pay fees. Users are rewarded for solving challenging mathematical problems. Bitcoin users receive bitcoins upon transaction verification. After four years or 210000 blocks, the award is halved. To boost bitcoin value and demand. Rewards vary. Because miners' profit from mining, the system is popular.

How rewards are calculated?

Let's pretend a customer has to make a purchase. For this particular deal, a "block" is generated. Every user receives the block at the same time. The customers guarantee the authenticity of the deal. If a deal goes through, the users who had a hand in making it will receive rewards. Incentives can be distributed more fairly with the use of protocols. After authentication is accomplished, the database is updated and the deal is finalized. It's important to remember that the award is not constant because it varies depending on the project. The block reward is based on a number of variables, including the overall supply of cryptocurrency, the average production time of crypto assets, and transaction fees.

Blockchain Forking

One way to "fork" a blockchain is to create a copy of the code and then modify it in order to create a new piece of software or product through the process of "forking." Creating a "fork" of an open-source project is a common and extensively observed practice that has gained widespread popularity. Open-source, distributed ledger technology is the foundation upon which cryptocurrencies such as Bitcoin and Ethereum are constructed. This means that everyone has the ability to make modifications to the protocol. Due to the fact that they are open-source projects controlled by the community, they are dependent on users to enhance the dependability and safety of the software. One additional advantage of open source software is that it can be forked in order to enhance the user interface. This feature makes the software more interesting and appealing to a larger audience. People are able to see, modify, or otherwise alter the code in an open source environment without the fear of punishment from the original creator. This is because the code is freely available to everyone. Generally speaking, there are two types of forks: those that occur in the codebase and those that occur in the live blockchain. Live Blockchain Forks are further subdivided into Accidental Forks and Intentional Forks, and then Intentional Forks are further subdivided into Soft Forks and Hard Forks.

Codebase Fork

This entire code of the present blockchain is replicated and adjusted in order to reduce the amount of time required to build blocks. Additionally, some significant modifications were made, and a faster software was developed in comparison to the existing blockchain. This software was then launched as a new whole program that was labelled against you. In this way, a new blockchain is created when the ledger is empty. By forking the code of Bitcoin and making some minor tweaks, a significant number of the ALT COINS that are currently on the blockchain were produced.

Live Blockchain Fork

It is important to note that the term "Live Blockchain Fork" does not relate to a particular kind of fork; rather, it describes the occurrence of a split in a blockchain network that is currently functioning and actively processing transactions. In the context of a live blockchain fork, the term "live" refers to the fact that the fork is occurring in real time and has an impact on the blockchain's capability to continue functioning normally. When a live blockchain fork takes place, it indicates that there is a split in the blockchain, either temporary or permanent, and that two or more copies of the chain are being actively maintained and updated.

Accidental Fork/Temporary Fork

Forks that arise accidentally as a result of network delay or synchronization issues leading to momentary divergences are referred to as forks. It was neither intended or begun by the developers, hence it was unintentional. Resolves itself when the network converges on a single chain, making it both temporary and permanent. popular in Proof-of-Work: This type of consensus technique is also more popular in proof-of-work systems.



**Maitri Hingu and Kamlendu Pandey****Intentional Fork**

Intentional or planned forks are planned and executed with a specific purpose in mind. They are begun on purpose by developers or members of the community with the objective of implementing upgrades, improvements, or changes to the protocol. Regarding the impending fork, developers and the community typically communicate with one another a significant amount of time in advance. In order to prevent contentious situations, it is often necessary to have widespread consensus. So intentional fork has two types:

Soft Fork

To provide a definition, a soft fork is an upgrade to the blockchain protocol that is compatible with previous versions. It makes the restrictions more stringent, rendering blocks that were previously valid invalid. Even though they have not updated, nodes that have not upgraded can still interact with upgraded nodes without causing the network to completely split apart. It enables upgraded nodes to coexist alongside non-upgraded nodes inside the same network. Soft forks are reversible, meaning that they can be undone if the network itself decides to go back to the previous regulations. The term “consensus rule changes” refers to modifications that are more stringent than the regulations that are now in place.

Hard Fork

According to the definition, a hard fork is a permanent divergence in the blockchain that results in two distinct chains that are incompatible with one another. It requires making modifications to the protocol that are not compatible with previous versions of the protocol. This means that nodes who do not upgrade will regard the new blocks to be invalid. Hard forks are irreversible, meaning that once they occur, the split is irreversible. Additionally, hard forks frequently bring about the introduction of new features, rules, or upgrades. A large number of parties must reach a consensus in order for the implementation to be successful.

Why we need blockchain forking?

In the process of developing software, forking is an extremely important component that serves a variety of important functions. It makes it possible for developers to work together independently on features or bug fixes without having an effect on the primary codebase, which helps to cultivate an environment that is both flexible and parallel in nature. When it comes to open source contributions, forking is especially useful because it enables developers to create their own versions, test modifications, and submit pull requests for evaluation and inclusion in the original project. Forking also allows for experimentation, which means that it provides an area where modifications can be tested before they are merged into the parent repository. When it comes to maintaining personalized versions of projects that are adapted to their particular requirements, developers also make use of forks. The idea is frequently utilized for the purpose of providing new features and performing bug fixes, both of which contribute to the overall development of a project when implemented. A transparent history of changes and individual contributions is provided via forks, which contribute to successful version control. In addition to this, they make decentralized development easier to do, which enables many teams or developers to separately work on various areas of a project. Additionally, forking serves as a risk mitigation approach, acting as a safety net in the event that disagreements arise or the project is potentially abandoned. In [21], examines the state-of-the-art in blockchain technology and introduces decentralized applications. The only way for current blockchain systems to upgrade is through a hard fork because of the P2P consensus model [21]. Recent efforts have been made to enhance the functionality of existing blockchains with the potential for anonymity [21]. A blockchain is a continuously expanding chain of blocks, each of which contains a cryptographic hash of the one before it, a time stamp, and the data it delivered [21]. The blockchain infrastructure must be able to accommodate millions of daily active users in order to support contemporary web-based systems like social networks, massively multiplayer online games, and online retail malls [21]. Response times from each network node affect a DApp's sequential performance [21].



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DISCUSSION

The complex structural features of blockchain technology highlight its significance as a revolutionary invention in the digital era. The decentralized and cryptographic underpinning of blockchain architecture provides a strong platform for secure and transparent transactions. When analyzing the basic elements of blockchain, such as blocks and chains, we observe how data integrity and immutability are preserved through cryptographic hashes, effectively preventing tampering without being detected. Consensus mechanisms, a crucial element of blockchain structure, have seen substantial development since the creation of Bitcoin's Proof of Work (PoW). Although Proof of Work (PoW) has proven the practicality of decentralized consensus, it frequently faces criticism because to its substantial energy consumption. The adoption of Proof of Stake (PoS) and other consensus algorithms, such as Delegated Proof of Stake (DPoS), Practical Byzantine Fault Tolerance (PBFT), and emerging innovations like Proof of Authority (PoA), demonstrates the continuous endeavors to enhance the efficiency, scalability, and security of blockchain networks. Every consensus process possesses distinct advantages and drawbacks, which have an impact on the structure and capabilities of different blockchain systems. The issue of scalability continues to be a significant obstacle for blockchain technology. As blockchain networks expand, there is a greater need for computational capacity and storage, which can result in possible obstacles. Layer 1 techniques, like as sharding, seek to partition the network into smaller, more controllable segments, thus enhancing transaction throughput. Layer 2 technologies, including as state channels and sidechains, provide alternative methods to improve scalability by handling transactions outside of the main blockchain while still ensuring security and trust. These technological improvements are essential for empowering blockchain to effectively manage the requirements of extensive applications and universal acceptance. The security of blockchain technology has both positive and negative aspects. On one side, the cryptographic concepts that form the foundation of blockchain technology offer strong safeguards against unwanted alterations. However, the decentralized structure of blockchain allows for potential exploitation of vulnerabilities in smart contracts or consensus processes if they are not properly handled. The continuous advancement of formal verification approaches and new cryptographic techniques seeks to enhance the security of blockchain systems, guaranteeing their ability to endure intricate attacks.

CONCLUSION

The purpose of this survey paper was to investigate the various aspects of blockchain technology, including its history, its current state, and the possible developments that could occur in the future. The adaptability and transformative potential of this decentralized technology has been brought to light through the exhaustive investigation of a variety of blockchain platforms, consensus processes, and applications in the real world. Through the course of this research, a thorough analysis of the existing literature concerning the numerous applications of blockchain technology was carried out. Even though it has only been ten years since the blockchain technology was first developed, businesses are constantly looking for methods to adopt it in order to better their operations. Because of the increasing amount of digital information that we encounter in our everyday lives, there is a growing demand for blockchain technology that is capable of securing, accessing, transparently recording, and accurately recording data. Blockchain engineers and specialists continue to be in short supply on the job market, despite the fact that the technology is making significant progress. There will be a return on investment in the Blockchain technology in the future. The time has come to familiarize oneself with the technology behind blockchain-based transactions. The usage of blockchain technology will become more widespread in the years to come, and the advantages that results from its implementation will encourage businesses and organizations from all over the world to make investments in the technology. Despite the fact that blockchain technology is still in its infancy, it is expected to encounter widespread adoption from a variety of industries all over the world in the not too distant future. As a result of our investigation, it is clear that blockchain technology has moved beyond its initial link with cryptocurrencies and has expanded into other fields, including supply chain management, healthcare, banking, and other areas. The literature that was reviewed highlights the robustness, transparency, and security improvements that blockchain technology delivers to



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a variety of different businesses. In addition, the difficulties and constraints that were discovered in this survey shed light on crucial areas that require further investigation and invention in the months to come. There are still important obstacles that the blockchain community needs to work together to overcome in order to realize the full potential of this ground-breaking technology. These obstacles include scalability, interoperability, and regulatory frameworks. As we make our way through the ever-changing world of blockchain technology, it is becoming increasingly apparent that collaboration between researchers, developers, policymakers, and industry stakeholders is very necessary. The only way we will be able to overcome the obstacles, improve the solutions that are already in place, and pioneer new applications that will lead to the development of decentralized systems in the future is through collaborative efforts. In conclusion, this study is an invaluable resource for academics, industry professionals, and enthusiasts who are interested in gaining a comprehensive grasp of the blockchain ecosystem. Allow this poll to serve as a compass for us as we move on with the next phase of blockchain innovation. It will inspire further exploration and advancements that will definitely reimagine the ways in which we communicate with one another, do business, and trust one another in the digital world. The voyage of blockchain is not even close to being finished, and as we consider the thoughts that have been offered in this article, we expect that this revolutionary technology will have a future that is both exciting and transformative.

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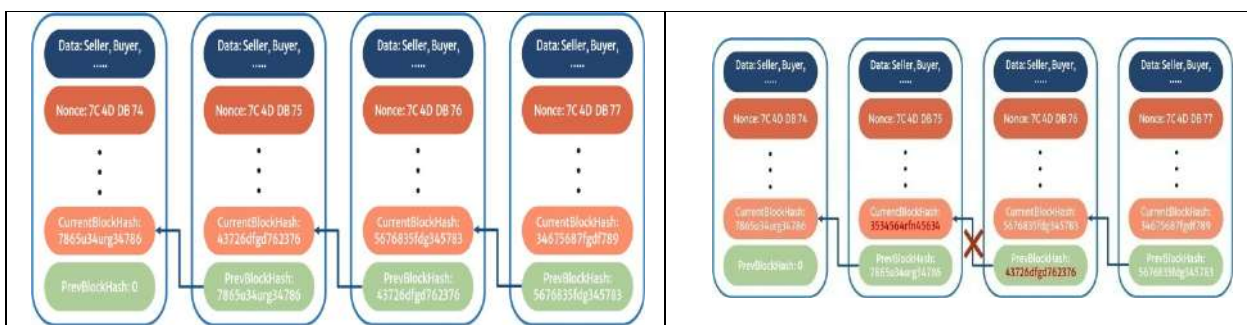


Fig.1.Example of Blockchain where all hashes are in sync

Fig.2.Example of Blockchain where hash doesn't match.

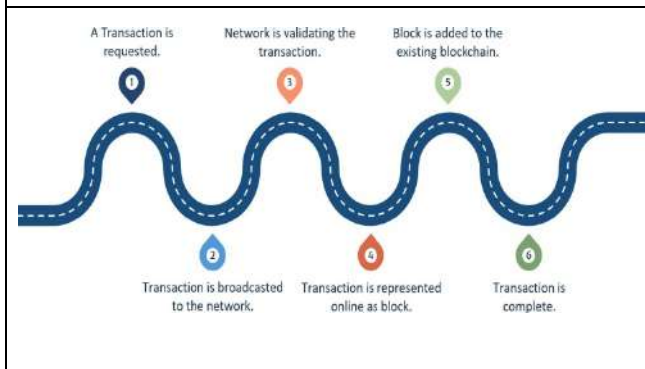


Fig.3.Road map of Blockchain accepting transactions insidenode

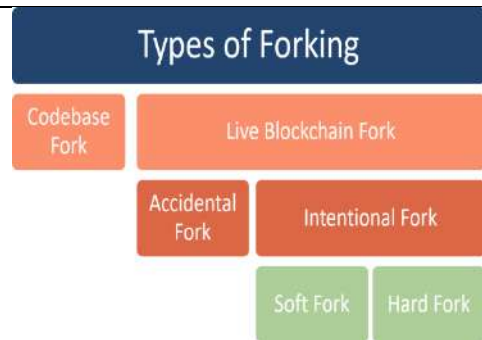


Fig.4.Types of Blockchain Forking





Growth, Thermal, Optical, Photoluminescence and cv Studies of Thiourea - Doped Vanadyl Sulphate (TVS) Single Crystal

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ABSTRACT

Thiourea-doped vanadyl sulphate (TVS) crystals were grown by the solution growth method. Transparent light blue crystal of TVS was harvested in the period of 20 days. Thermal stability and the melting point of TVS crystal have been studied by Thermogravimetric analysis (TGA) and differential thermal analysis (DTA) techniques. TVS crystal's optical properties and optical constants such as band gap (E_g), refractive index (n), reflectance (R), absorption coefficient (α), extinction coefficient (K) were determined by UV-VIS-NIR spectrum. Photoluminescence spectroscopy investigates the luminescence nature of the TVS crystal. The electrochemical behavior of the TVS crystal was investigated by cyclic voltammetry.

Keywords: Crystal growth; Doping; NLO; TG/DTA; spectroscopy; PL; CV





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INTRODUCTION

Vanadyl sulphate is an inorganic compound which has the chemical formula of $\text{VOSO}_4 \cdot (\text{H}_2\text{O})_x$ where $0 \leq x \leq 6$. Vanadium can be found in several forms, such as vanadate and vanadyl sulphate. The most common source of vanadyl sulphate is found in nutritional supplements. Vanadium is a metallic element that is used because of its interesting physical, chemical and biological properties [1]. By Peder Kierkegaard et al., the crystal structure of pure vanadyl sulphate (VOSO_4) was dissolved. He discovered that it is a part of the orthorhombic structure [2]. The synthesis and characterisation of $\text{VOSO}_4 \cdot 6\text{H}_2\text{O}$ and other Vanadium(II) Compounds were also reported by Albert Cotton et al.[3]. Vanadyl sulphate hexahydrate ($\text{VOSO}_4 \cdot 6\text{H}_2\text{O}$) was generated by Michel Tachez et al. from an aqueous solution at 0°C , and they investigated the material below 13°C . They observed that the $\text{VOSO}_4 \cdot 6\text{H}_2\text{O}$ crystallized in a triclinic form[4]. Vanadium(IV) was obtained by Krasil'nikov et al. using $\text{VOSO}_4 \cdot 3\text{H}_2\text{O}$ as a source and aqueous ammonia as a precipitant for the $\text{VO}(\text{OH})_2$ production[5]. Lee M. Daniels et.al reported the preparation and characterization of anhydrous vanadium (II) compounds by reaction of aqueous solutions of $[\text{V}(\text{H}_2\text{O})_6]\text{SO}_4$ with neutral amines[6]. The crystal growth and characterization of potassium zinc- vanadyl sulphate mixed crystal have also been reported by Vijila Manonmoni et.al[7]. In our earlier study, we have reported the analysis of structure, UV Transmittance of its aqueous solution, FTIR and Microhardness of thiourea -vanadyl sulphate (TVS) single crystals[8]. In this work, we have reporting the optical constants of UV Transmittance of single crystal, thermal, photoluminescence and electrochemical behaviour of TVS single crystals.

SYNTHESIS AND CRYSTAL GROWTH

Thiourea doped vanadyl sulphate single crystals have been synthesized by taking Analytical reagent grades (AR) of Thiourea and Vanadyl Sulphate. The homogeneous saturated solution was prepared at room temperature using a magnetic stirrer. A saturated solution was filtered to remove the impurities. Then the filtered solution was allowed to slow evaporation solution growth technique. Within 20 days good quality and a light blue optically transparent of Thiourea doped vanadyl sulphate single crystal were harvested. The photograph of grown crystals is shown in figure 1.

RESULTS AND DISCUSSION

Study of Thermal behaviour of TVS crystal

Using a NETZSCH STA 2500 thermal analyzer in a nitrogen atmosphere, the thermogravimetric and differential thermal studies of TVS crystal were performed. The sample was heated at a rate of 30 K/min between 30 and 500°C . The TGA spectrum (Figure 2) shows that there is no weight loss up to 123.83°C , confirming that the molecule in question does not include any water or crystallization. After that, weight drops in three stages, from 123.83°C to 356.8°C . Due to glass transition, only 10% of the mass is lost in the first stage between 123.83°C and 181.33°C . The DTA curve shows two abrupt endothermic peaks at 181°C and 202°C , respectively, which correlate to the rapid mass loss of 69.6% between 181.33°C and 223.83°C . These peaks are due to and melting and decomposing respectively. This indicates that the crystal has developed with a good degree of crystallinity. The temperature range in which the gradual weight loss takes place is 223.83°C to 356.8°C . Because of the compound's impurities and the release of volatile compounds like sulphur, the DTA curve in this phase exhibits a slight endothermic at 267°C [9 - 11]. After this peak, there is a broad endothermic peak at 436°C corresponding to this peak there is no weight loss occur in TGA. It has been shown that the state of total weight loss corresponds to 99.7% of the growing crystal. The compound is seen to be stable up to 123.83°C and to melt at 181°C based on the DTA/TGA trace.

Determination of kinetics and thermodynamics parameters

According to the reaction theory, kinetic equation for decomposition of solid matter is usually written as [12]

$$\frac{dx}{dt} = k(1 - x) \quad (1)$$





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Where, $x = \frac{m_0 - m_T}{m_0 - m_f}$

m_T is the mass of sample at any temperature T and m_0 and m_f are the masses at initial and final temperatures respectively [13]. Eq. (1) was integrated to give:

$$\ln(1 - x) = -kt \quad (2)$$

The straight line that each phase's data followed on graphs created with equation (2) indicated that transformations were first-order reactions. Each line's slope revealed the rate constant (k) for that phase (Figures 3-5) and equation (3) was used to calculate the half-life time ($t_{1/2}$).

$$\text{Half life Time } t_{1/2} = \frac{0.693}{k} \text{ s.} \quad (3)$$

The activation energy and thermodynamic parameters were then determined using the Coats-Redfern method [14,15].

$$\ln[-\ln(1 - x)] = \ln \frac{A R T^2}{\beta E_a} - \frac{E_a}{R T} \quad (4)$$

Where A is frequency factor, β is heating rate ($20^\circ\text{C}/\text{min}$), R is general gas constant ($8.3143 \text{ Jmol}^{-1}\text{K}^{-1}$), E_a is activation energy and T is temperature (K). Plotting graphs between $\ln[-\ln(1-x)]$ vs $1000/T$ for each phase (Figures 6-8) gave the values of activation energy. Thermodynamic parameters are evaluated by the following basic thermodynamic equations [16].

Activation energy = slope $\times 8.3143 \text{ (Jmol}^{-1}\text{)}$

The standard entropy of activation, ΔS , is calculated from the following relation

$$\Delta S = R \times \ln \frac{A h}{k T} \text{ Jmol}^{-1} \text{ K}^{-1} \quad (5)$$

Where, k is the Boltzmann constant ($1.38 \times 10^{-23} \text{ J/K}$) h is the Planck's constant ($6.63 \times 10^{-34} \text{ m}^2 \text{ kg / s}$) and T the temperature and A the frequency factor.

The standard enthalpy of activation,

$$\Delta H = E_a - 2RT \text{ Jmol}^{-1} \quad (6)$$

The standard Gibbs energy of activation,

$$\Delta G = \Delta H + T \Delta S \text{ Jmol}^{-1} \quad (7)$$

The calculated values of rate constant k , Activation energy E_a and the thermodynamic parameters are tabulated in table 1. The higher value of activation energy for the grown crystal indicates more stable nature and all phases are non-spontaneous endothermic reactions.

UV-VIS UV TRANSMITTANCE STUDY OF TVS SINGLE CRYSTAL

The UV-Visible spectral analysis gives useful information about electronic transitions of the compound and is assisted to understand the electronic structure and optical band gap of the crystal [18]. For laser frequency conversion applications, the transmission range, absorbance band, and transparency cut-off are crucial optical parameters [17,18]. Using a Shimadzu UV-2450 spectrophotometer, the linear optical property of the TVS single crystal was investigated in the 200–1100 nm wavelength range. The obtained UV-Vis NIR transmittance spectrum is shown in Figure 9.

It is evident from the spectrum that, the formed crystal exhibits strong optical transmission over the whole visible and near-infrared range. At a certain critical wavelength, the transmittance intensity totally vanishes. It was discovered that the material's cut off wavelength, or critical point, was 393 nm. The electrons in the σ and π orbitals must be promoted from the ground state to the excited state via absorption, which requires a significant amount of energy. We refer to this procedure as a charge transfer excitation. Absorption bands resulting from $\pi \rightarrow \pi^*$ and $n \rightarrow \pi^*$ transitions involving π -orbitals and lone pairs (n = non-bonding) in particular are significant. Chromophores are defined as molecules that may display the electronic transitions mentioned above [19]. The presence of chromophores like VO_2 anion may be the cause of the violet crystal's appearance.

DETERMINATION OF OPTICAL BANDGAP AND OPTICAL CONSTANTS

Optical band gap energy

Optical properties are very essential to determine a material's suitability for use in the fabrication of optoelectronics. The photon energy ($h\nu$) determines the optical absorption coefficient (α), which is useful in determining the type of





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electron transition and band structure [20]. The optical absorption coefficient (α) was calculated from the measured transmittance (T) using the relation.

$$\alpha = \frac{2.303 \times \log\left(\frac{1}{T}\right)}{d} \text{m}^{-1} \quad (8)$$

Where T is the transmittance and t is the thickness of the crystal. According to Tauc's relation, the value of α was used to determine the optical band gap [21].

$$(\alpha h\nu) = A(h\nu - E_g)^m \quad (9)$$

where α is the absorption coefficient, $h\nu$ is photon energy, E_g is the optical band gap energy, A is a constant and m is the optical transition number. When electromagnetic radiation enters materials, it is absorbed at a specific wavelength when its energy is equivalent to the materials' optical band gap energy. The electrons undergo valence band to conduction band transitions. There are two types of electron transitions between the valence and conduction bands: direct and indirect, with both having a prohibited transition. For the direct allowed transition, indirect allowed transition, direct forbidden transition, and indirect forbidden transition, respectively, the transition number (m) is 1/2, 2, 3/2, and 3. The type of optical transition of the TVS crystal is determined by the value of m, which needs to be determined in this instance. Taking logarithm on both sides and differentiating equation (10) with respect to $h\nu$ we get the following form [22-24]

$$\ln(\alpha h\nu) = \ln(A) + m \ln(h\nu - E_g) \quad (10)$$

$$\frac{d(\ln(\alpha h\nu))}{d(h\nu)} = \frac{m}{h\nu - E_g}$$

A graph depicted in Figure 10 that is plotted between $(\ln(\alpha h\nu))/h\nu$ and $h\nu$ can be used to compute the value of E_g . The information regarding single and multiple stage optical transitions is provided by the discontinuity in the line. These transitions are specified for a given value of m, which corresponds to a specific maximum energy value at which a given transition may have occurred [25,26]. In the current instance, the optical transition consists of a single stage that discontinuously occurs at a certain maximum energy value of the knee point ($E_g = 3.13\text{eV}$). Plotting the graph between $\ln(\alpha h\nu)$ and $\ln(h\nu - E_g)$, the value of m is obtained. The value of m was found to be $0.54 \approx 0.5 \approx 1/2$ by extrapolating linear fit as shown in Figure 11. This shows and confirms that the optical transition of TVS crystal is allowed for direct band gap nature. The Tauc's plot relation has been rearranged as given below for condition of direct allowed transition:

$$(\alpha h\nu) = A(h\nu - E_g)^{1/2} \quad (11)$$

The bandgap (E_g) of the grown crystal was estimated by plotting $(\alpha h\nu)^2$ versus $h\nu$ as shown in Figure 12. The value of the bandgap of grown crystal was found to be 3.04eV.

According to Plank's equation, the optical band gap energy of TVS crystal was calculated theoretically as follows:

$$E_g = \frac{1240}{\lambda} \text{eV} \quad (12)$$

where λ is the lower cut-off wavelength (393 nm). The band gap of the grown TVS crystal is found to be 3.16 eV, which is in good agreement with the value obtained from Figure 10 and Figure 11.

Determination of optical constants

Extinction coefficient is the measure of how strongly a chemical species or substance absorbs light at particular wavelength. It depends upon the structure and chemical composition of a substance or material [27-31]. By using absorption coefficient value the Extinction coefficient can be determined by the formula

$$k = \frac{\alpha \lambda}{4\pi} \quad (13)$$

where k is Extinction Coefficient, α is absorption coefficient, λ is wavelength. The variation of extinction coefficient (K) with wavelength is shown in Figure 13.

Optical Refractive Index and Reflectance

Refractive index (n) and Reflectance (R) are determined by using formulas

$$n = \frac{1}{T_s} + \sqrt{\frac{1}{T_s} - 1} \quad (14)$$





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$$R = \frac{(n-1)^2}{(n+1)^2} \quad (15)$$

The wavelength versus reflectance is shown in Figure 14. Figure 15 represents the variation of the refractive index as a function of photon energy. The linear refractive index (n) of the grown crystal was found to be 0.7 at the energy gap $E_g = 3.13$.

PHOTOLUMINESCENCE SPECTROSCOPY

A useful technique for obtaining reasonably direct information about the molecular-level physical properties of materials, such as band gap states and shallow and deep level defects, is photoluminescence (PL) spectroscopy [32–34]. The photoluminescence (PL) spectrum of TVS recorded using a Cary Eclipse spectrophotometer in the range between 250–500 nm with excitation wavelength of 270 nm is 4.59 eV at room temperature is shown in Figure 16. The highest emission peak from the spectrum was observed to be at 428 nm is 2.90 eV are due to violet emission and no other visible emission was observed. The relationship between energy (in eV) and wavelength (in nm) given by the equation,

$$E_g = \frac{hc}{\lambda} \quad (16)$$

Where E_g is the energy in units of eV, or electron volts, λ is the wavelength measured in nanometers (nm), and c is the velocity of light, which has units of ms^{-1} . The sharp single peak shows the good quality of TVS crystal.

CYCLIC VOLTAMMETRY

The cyclic voltammetry is used to investigate the electrochemical behavior of a system by methodically examining the current-voltage data of a specific electrochemical cell. The CV investigation was carried out using a linear scan rate that ranges from 0.01 V s^{-1} to 0.2 V s^{-1} within a voltage window of -1.5 to 2.0 V . A graph between current and potential is known as cyclic voltammogram (Figure 17) depicts the CV curves measured at different scan rates. When a slow scan rate (0.01 V s^{-1}) is applied to the device, a rapid increase in the current density versus potential gives an oval-shaped curve. Consequently, the slow scan rates cause the current to flow through the device in a resistive manner. As the operating time is gradually maximized and also scan rate is increased, more rectangular shaped curves can be obtained from the CV scans [35–38].

The specific capacitance obtained from CV measurement was calculated according to this Equation

$$C_{\text{specific}} = \frac{A}{\Delta V \times s \times m} \quad (17)$$

where ΔV is the potential range (V), A is the area of integration, s is the scan rate (V s^{-1}), m (g) is the mass of the sample. Table.2 shows the specific capacitance of the grown crystal. The specific capacitance of the TVS crystal has reduced from 0.8219 Fg^{-1} to 0.0263 Fg^{-1} with an increase in scan rate of 0.01 V s^{-1} to 0.2 V s^{-1} . This is because, the ions are more accessed to the active materials through pores at a lower scan rate. The results indicate that the grown crystal achieve a higher specific capacitance of 0.8219 Fg^{-1} at 10 mV/s .

CONCLUSIONS

Single crystal of thiourea-doped vanadyl sulphate was successfully grown by slow evaporation solution growth method at room temperature. The crystals were found to be transparent and a light blue colour. The thermal stability of thiourea-doped vanadyl sulphate crystal was estimated using TGDTA Analysis. the TVS crystal is thermally stable up to 123.83°C . From the DTA curve, reveals that, the sample melts at 202°C and the decomposition states at this temperature. Hence, the crystal has a good degree of crystallinity and is also thermally stable for device application. The rate constant and the half lifetime of reaction were calculated from the TGA data. From the TGA curve, kinetic parameters were determined using basic thermodynamic equations and the values obtained for each phase proved that the first and second phases are non-spontaneous endothermic reactions and the third phase transition is a spontaneous exothermic reactions. UV–Vis NIR spectrum shows that the crystal becomes transparent in the entire Vis-IR region and the cut-off wavelength was found to be 393 nm . The grown crystal has good optical transparency and hence it is suitable for NLO applications upto 393 nm . The optical band gap was calculated using Tauc's plot relation and it is found to be 3.04 eV . TVS crystal has lower cut-off wavelength is found to be 393 nm and a calculated



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Energy band gap of 3.16eV was determined in UV–vis studies which suggested the material is suitable for laser frequency doubling and related optoelectronics applications. The photoluminescence spectrum shows the violet emission for the TVS crystal. According to the cyclic voltammetry investigation, the TVS crystal exhibits a higher specific capacitance of 0.8219 Fg⁻¹ at 10 mV/s.

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Table 1. Kinetic and Thermodynamic Parameters of Each Phase During Thermo gravimetric Analysis of Tvs Crystal

Phase	Tem (K)	Rate constant k	$t_{\frac{1}{2}}$ (secs)	E_a (Jmol ⁻¹) X 10 ³	ΔS (Jmol ⁻¹ K ⁻¹)	ΔH (Jmol ⁻¹) X 10 ³	ΔG (Jmol ⁻¹) (×10 ⁴)
1	454.33	0.01579	2633.31	120.143	50.89	112.752	13.58
2	496.83	0.416231	99.8964	117.377	50.56	109.295	13.44
3	629.333	0.307	135.43	22.605	-182.34	12.366	-10.23

Table.2: Specific Capacitance Measured From Cv Under Different Scan Rate

Scan rate (V s ⁻¹)	specific capacitance (F g ⁻¹)
0.01	0.821917808
0.02	0.46582795
0.03	0.369989723
0.04	0.283174185
0.05	0.235139573
0.06	0.205801861
0.08	0.167103539
0.1	0.056164384
0.2	0.026257815



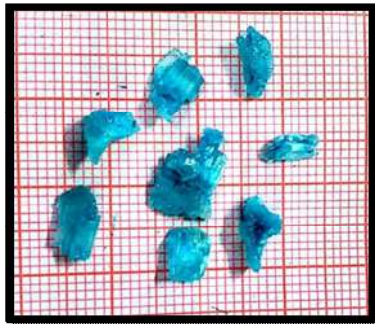


Figure 1. Photograph of TVS single crystals.

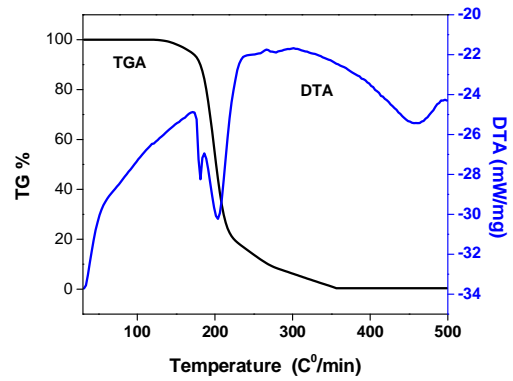


Figure 2. Thermal plots for TG/DTA

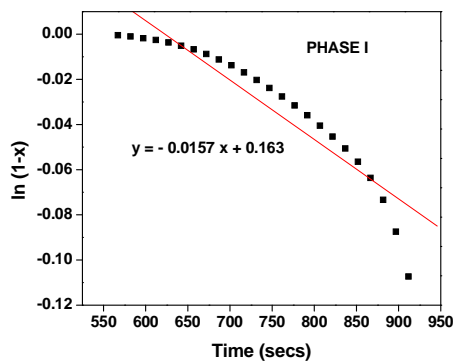


Figure 3. Plot of $\ln(1-x)$ vs Time for Phase I.

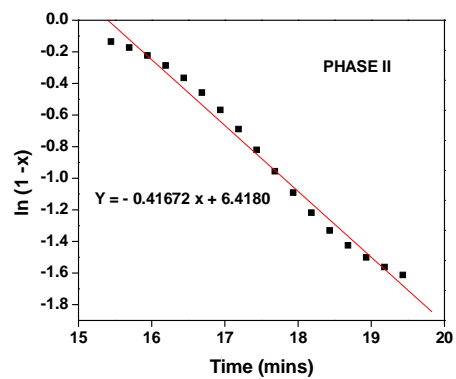


Figure 4. Plot of $\ln(1-x)$ vs Time for Phase II

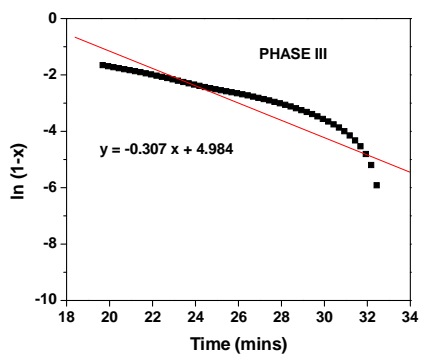


Figure 5. Plot of $\ln(1-x)$ vs Time for Phase III

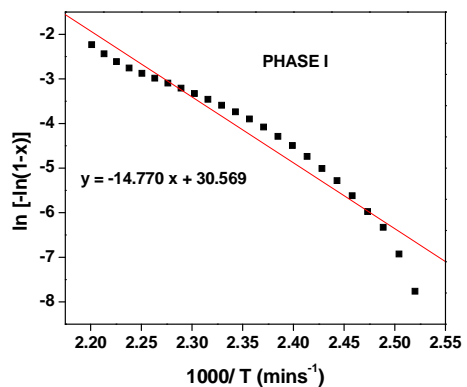


Figure 6. Plot of $\ln[-\ln(1-x)]$ vs $1000/T$ for Phase I





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<p>Figure 7. Plot of $\ln[-\ln(1-x)]$ vs $1000/T$ for Phase II</p>	<p>Figure 8. Plot of $\ln[-\ln(1-x)]$ vs $1000/T$ for Phase III</p>
<p>Figure 9. Transmittance spectrum of TVS crystal</p>	<p>Figure 10. plot of $\ln(\alpha hv) / hv$ vs. $h\nu$</p>
<p>Figure 11. Plot of $\ln(\alpha hv)$ vs. $\ln(h\nu - E_g)$</p>	<p>Figure 12. Plot of $(h\nu)$ vs. $(\alpha hv)^2$</p>





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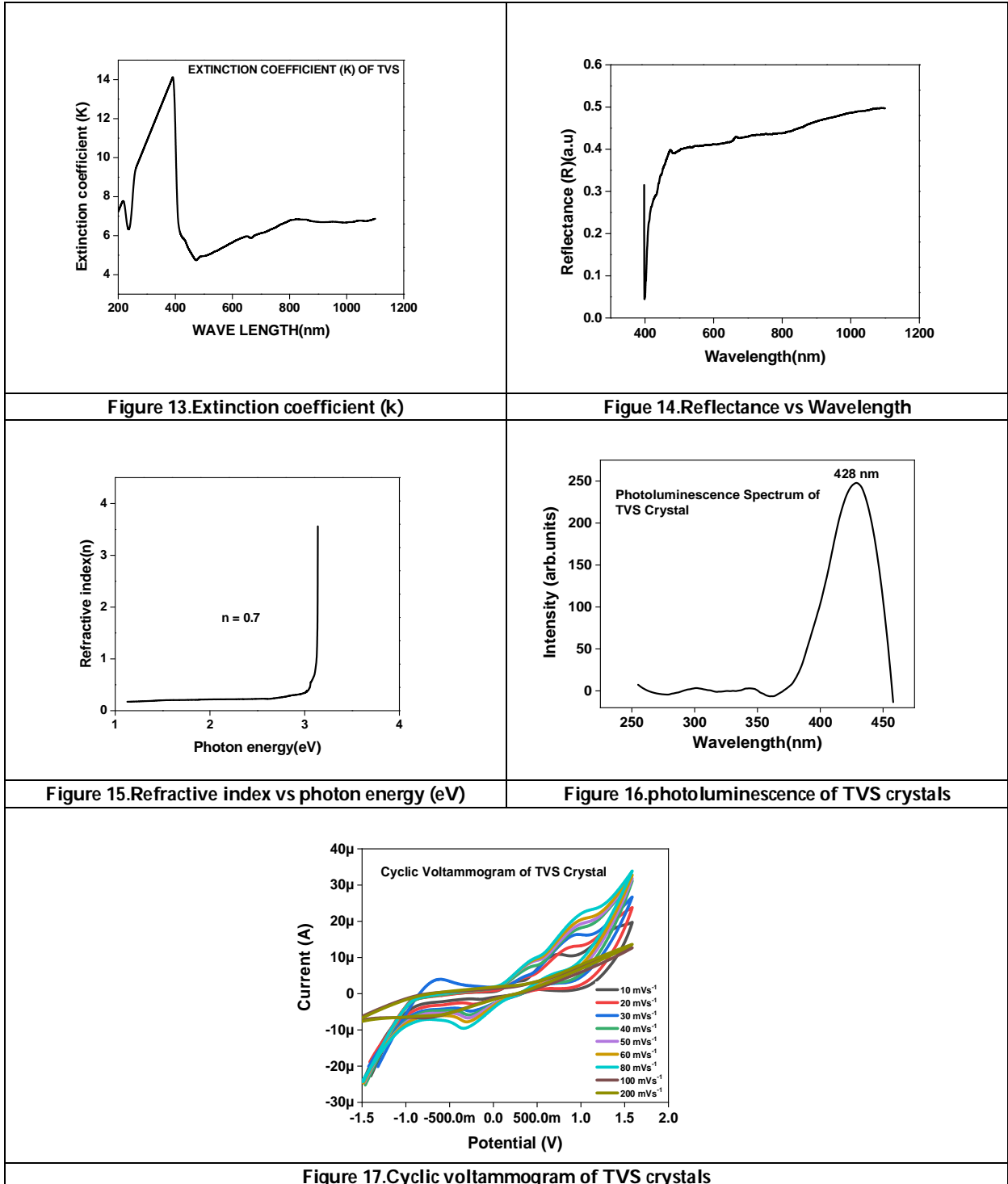


Figure 13. Extinction coefficient (k)

Figure 14. Reflectance vs Wavelength

Figure 15. Refractive index vs photon energy (eV)

Figure 16. photoluminescence of TVS crystals

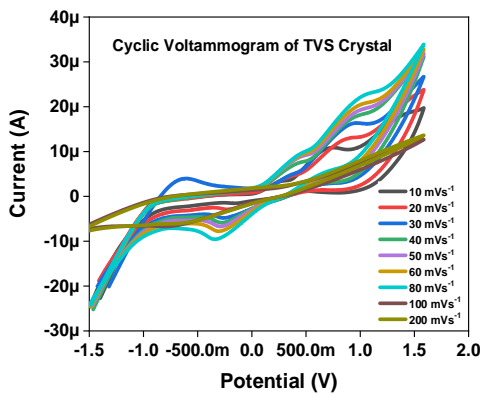


Figure 17. Cyclic voltammogram of TVS crystals





A Study on Knowledge, Awareness, and Practices of Menstrual Hygiene among the Adolescent Girls of Kamrup (Rural) District, Assam

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ABSTRACT

Menstruation is a natural physiological process for females of reproductive age, and it is necessary to understand hygienic practices and risks associated with menstruation. Data collected from adolescent girls (above 12 years of age) in a peri-urban girls' high school were selected through random sampling using a self-administered questionnaire. In this study, despite having 100% literacy, only 45.58 % of the adolescent girls had prior knowledge of menstruation before menarche. Knowledge about the cause of menstruation among adolescent girls is not satisfactory, as 34.8% of them did not know about the cause of menstruation and 63.7% of them believed that it was a natural process. In addition, 50.2% of them did not know about the cause of menstruation. 93.4% of the adolescent girls were ignorant about the source of menstrual bleeding and only 1.8% of the adolescent girls knew that the bleeding comes from the uterus. On a positive note, 79.5% of the adolescent girls preferred using sanitary pads, 16.2% used both sanitary pads and cloth, while 4.18% preferred using cloth. It is also observed age $p \leq (0.004)$ and class of adolescent girls $p \leq (0.010)$ are significantly associated with the types of adsorbents used. Yet, prior knowledge of menstruation $p \leq (0.0590)$ is not significantly associated with the types of adsorbents used. It is encouraging that 92.3% of participants preferred cleaning the reused clothes with soap and water, and 97.36% of the girls practiced drying the washed clothes in sunlight. Among the respondents who used sanitary napkins, 73.48% changed it 2-3 times per day whereas, 19.06% changed it 4-5 times per day, and 3.72% changed it 1 time per day. Prior knowledge of menstruation $p \leq (0.001)$, age $p \leq (0.007)$, Educational Status of the adolescent mother $p \leq (0.057)$, and agents used to clean genitalia $p \leq (0.051)$ is significantly associated with satisfactory cleaning of external genitalia. 95.34% of Adolescent girls were restricted from



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being involved in religious practices. The study concludes that though the adolescent girls are 100% literate their lack of knowledge regarding menstruation and the hygiene practices exhibited among them were not satisfactory. Hence, there is a need to educate girls as well as mothers on menstruation and create awareness of menstrual health and hygiene.

Keywords: Adolescent girls, Genitalia, Menstrual health, Hygiene, Sanitary pad.

INTRODUCTION

Menstruation is a common and healthy phenomenon for women who are of reproductive age [1,2]. The transitional stage between puberty and adulthood is known as adolescence. Menarche is a significant event in the lives of teenage females that starts between the ages of 10 and 16 and it is one of the indicators of puberty [3]. A key variable influencing how an adolescent develops reproductively is having a regular menstrual cycle [4]. However, due to a lack of sufficient information, majority of teenage girls approach the puberty stage unprepared [5]. Due to social taboos surrounding the topic of "menses," most women find it uncomfortable to talk about it, and teenage girls may not have access to sufficient information [6,7]. Women's hygiene habits during their periods are very important since they affect their health by making them more susceptible to reproductive tract infections (RTI). It is evident how menstrual hygiene habits, socioeconomic position, and RTI correlate. Millions of women today suffer from RTI and its after-effects, and the infection frequently spreads to the mother's unborn child. Having access to the information, resources, and cultural settings needed to handle menstruation hygienically and dignifiedly is a top priority for women and girls [8]. Even the limited information they do acquire is frequently biased and surrounded by misconceptions, and it comes primarily from peers, family members, and religious institutions [9.] In addition, girls have frequently reported feeling scared, perplexed, and ashamed when going through their menstrual cycle due to unpleasant smells, leaks, clothing stains, and losing sanitary products during class [10]. Additionally, this may negatively affect their ability to focus, participate in class, and have confidence in their academic abilities [11]. Depending upon one's level of understanding and awareness, menstruation is associated with several myths and customs that can occasionally hurt one's health. For instance, in underdeveloped nations such as India and Ethiopia, menstruation is frequently seen as a sign of disease, a lifelong process, the outcome of a curse, or a punishment from God [9, 12-15]. Teenage girls believe that menstruation is something humiliating and should be kept private as a result, academic achievement, attendance at school, and social interactions are all further impacted by these circumstances [16]. Considering the foregoing, this study was conducted in the peri-urban girl's high school of the Kamrup (Rural) district of Assam to evaluate the knowledge and practices of teenage girls regarding menstrual hygiene, learn about the disorders they experience during their periods, and identify the factors linked to the current menstrual hygiene practices [17].

MATERIALS AND METHODS

Sampling and data collection

A Survey was conducted among 215 adolescent high school girls, classes 7-10 (above 12 years of age) in a peri-urban area selected through simple random sampling. Data was collected using a self-administered questionnaire. Factors for data analysis include awareness about menstruation prior to menarche, menstrual hygiene practices, type of absorbent used, and restrictions imposed during menstruation.

Ethical clearance

Appropriate ethical clearance was obtained for this work from the Institutional Human Ethical Committee (AdtU/Ethics/student-lett/2021/025; dated 29/05/2021) and informed consent from participants



**Ibasiewdor Mawlein and Nekita Sharma****Statistical analysis**

Data expressed in percentages “%” and “n” indicates the number of counts. Statistical analysis was done using SPSS for Windows and the association was determined using a chi-square test and P value <0.05 was considered significant for all tests.

RESULT AND DISCUSSION**Socio-demographic profile of the respondents**

In the present study, most of the adolescent girls taking part fall under the age group of 13-15 years at 84%, followed by <=12 with 10.23% and girls aged between 16 -18 with 6.04%. Data summarized in **Table 1** indicates a significant association (P=0.004) between the type of adsorbent used with age. Adolescent girls aged between 13-15 years showed 66.97% of the girls used sanitary pads and 2.79 % used cloth, and 14.14 % used both sanitary pads and cloth. The educational status of the adolescent girls also has a significant association ((P=0.010) with the type of absorbent used. Our data showed that 11.68 % of the girls were in class 7th, 25.23% in 8th, 39.7% in 9th, and 23.36% in 10th standard. These adolescent girls primarily used sanitary pads to maintain menstrual hygiene. Adolescent girls belonging to class 7, 8, 9, and 10 standards showed 10.69%, 18.60%, 34.41%, and 20.93% used sanitary pads (**Table: 1**). It is also observed age $p \leq (0.004)$ and class of adolescent girls $p \leq (0.010)$ are significantly associated with the types of adsorbents used (**Table: 2**). This data indicates that education plays an important role in attaining awareness about menstrual hygiene among the population.

Knowledge of adolescent girls about menarche and their perception about menstruation

Data summarized in Table 1 showed that 90% of the adolescent girls aged between 10-13 years had their menarche, followed by 14-15 with 9%, and girls aged between 16-17 years with 1%. A similar study in West Bengal showed the age of menstruating girls ranged from 14-17 years and the majority being between 14-15 years of age[5]. It is also important to note that only 45.58 % of the adolescent girls had prior knowledge of menstruation (Table: 1). before menarche. Yet, prior knowledge of menstruation is not significantly associated with the types of adsorbents used $p \leq (0.0590)$ (**Table: 2**). It is necessary that every girl be made aware of menstruation before menarche. Knowledge about the cause of menstruation among adolescent girls was not satisfactory, 34.8% did not know about the cause of menstruation. Whereas 63.7% believed it was a natural process, 0.93% accepted it as a curse of God and 0.4% had no response (**Table: 1**). A similar study conducted in West Bengal among school girls, 86.25% of respondents believed it was a physiological process. Prior information on menstruation can help create awareness of menstrual hygiene. However, our study indicates that 50.2 % of them obtained information on menstruation from other sources, followed by mothers (46.04%), friends (1.86%), and sisters (1.8%). Despite being 100% literate, 93.4% of the adolescent girls were ignorant about the source of menstrual bleeding. 4.1% thought that it came from the vagina, 0.46% from the urethra, and only 1.8% of the adolescent girl knew that the bleeding was from the uterus. This concludes that spreading awareness of menstrual health and hygiene is needed among school-going girls. It was disheartening that the literacy level of the mothers was >90% and majority of the girls were unaware of the source of their menstrual bleeding, which might be a result of lack of awareness and impulsively adhering to traditions. On a positive note, 80% of the adolescent girls preferred using sanitary pads, 16.2% used both pads and cloth, and 4.18% preferred using cloth. In addition, 70.27% of the adolescent girls preferred re-using the cloth (**Table 1**).

Practice of menstrual hygiene among the adolescent girls

Women's hygiene practices throughout their menstrual cycles are of the utmost importance since they impact their health by making them more susceptible to infections[8]. Data summarized in **Table 3** shows that among the adolescent girls who used cloth, 92.3 % of them preferred to clean the reused clothes with soap and water, while 7.69% of them washed the clothes with water only. 97.36% of the girls practiced drying the washed clothes in sunlight, and 2.63% m dried the clothes in the bathroom or beneath other clothes for fear of being seen by others. A similar study also revealed that 60% of adolescent girls preferred reusing clothes. Among them, 96.30% cleaned the reused clothes with soap and water, and 77.78%[17].



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Adolescent girls adopted various methods to dispose of sanitary pads, 50.01% preferred throwing it in with routine waste, 36.27% used to burn it while 13.72% preferred other methods. Similarly, of girls who used cloth but did not reuse it, 55.88% chose to dispose of the clothes by throwing them with routine waste, 29.41% burned it, while 14.7% preferred other methods such as not throwing or hiding it. In a similar study in Jorhat, Assam, 81.53% of girls using sanitary pads and 82.22% using clothes dispose of them by throwing them in with routine waste (Table 3). Among the respondents who used sanitary napkins, the majority (73.48%) changed it 2-3 times per day. Whereas 19.06% changed 4-5 times per day, 3.72% changed it 1 time per day and 3.72% of the girls had no response. Cleaning is an important part of maintaining the hygiene of the external genitalia. The frequency of cleaning was found to be satisfactory (≥ 2 times/day) in 95.34% of the adolescent girls, and 2.79% was unsatisfactory i.e., less than 2 times per day. It is important to note that 61.86% of the girls used soap and water to clean the external genitalia while 33.02% used only water, 4.18% used water and antiseptic for cleaning and 0.93% showed no response (Table 3). Prior knowledge of menstruation $p \leq (0.001)$, age $p \leq (0.007)$, is significantly associated with satisfactory cleaning of external genitalia (Table 4). It must be noted, educational Status of the adolescent mother $p \leq (0.057)$, and agents used to clean genitalia $p \leq (0.051)$ is not significantly associated with satisfactory cleaning of external genitalia.

Practice or any form of restrictions during menstrual period

Adolescent girls did practice some form of restriction, the most common prohibition was being involved in religious practices 95.34%. In addition, 45.11% of the girls were not allowed to attend marriages, and 57.67% were restricted from doing their regular household work. Touching sour food was restricted for 66.04% and, 57.20% were not allowed to enter the kitchen or cook food. 46.51% had separate beds, and 27.90% were not allowed outside the house. 39.53% of the girls were prohibited from playing either inside or outside the house and, 22.79% did not go to school during menstruation (Fig. 1). Similarly, 97.27% of adolescent girls practiced a similar form of restriction not attending religious ceremonies and marriage functions, not doing household work, not touching sour food, not entering the kitchen and most importantly they were not allowed to go to school during those days [17]. All those actions could relate to their beliefs and misinterpretation of the menstrual cycle.

CONCLUSION

Menstruation indicates healthy reproductive health. Knowledge, awareness, and practice of menstrual hygiene is a concern among school-going adolescent girls. According to our survey, the girls were unaware of menarche or the source of bleeding. Menstruation health issues, unsafe practices, traditional assumptions, and restrictions were commonly observed. Knowledge and awareness are the two key factors influencing menstruation habits and hygiene. Hence, our results highlight the necessity of continuous awareness of menstrual hygiene to eliminate outdated traditional beliefs and misconceptions. There is a need to focus on guiding how to use, access, and dispose of sanitary pads responsibly and encourage safe and improved menstrual hygiene.

Conflict of Interest

The authors declare no conflict of interest in this reported communication.

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Table: 1 Knowledge of respondents on the cause of menstruation

Age at menarche of adolescent girls (in years)	
10-13	90%
14-15	9%
16-17	1%
Knowledge of menstruation before menarche	
Yes	45.58%
No	54.41%
Knowledge of respondents on the cause of menstruation	
Curse of God	0.93%
Do not know	34.8%
Natural cause	63.7%
No response	0.4%
Information on menstruation	
Friends	1.86%





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Mother	46.04%
Sister	1.8%
None	50.2%
Organs from which the menstrual blood comes	
Do not know	93.4%
Urethra	0.46%
Uterus	1.8%
Vagina	4.1%
What do you use during menstrual period?	
Sanitary pad	80%
Cloth, Sanitary pad	16.2%
Cloth	3.73%
Reuse	
Yes	70.27%
No	29.72%

Data expressed in percentage “%”

Table: 2 Factor associated with type of absorbent used

Variables used	%	Absorbent used			P- value
		Sanitary pad n=172 (80%)	Cloth n=8 (3.73%)	Cloth and Sanitary pad n= 35 (16.2%)	
Age in years					
<=12	6%	10 (4.65%)	2 (0.93%)	9 (4.18%)	0.004*
13 -15	84%	144 (66.97%)	6 (2.79%)	31 (14.14%)	
16-18	10%	13 (6.04%)	0	0	
Educational Status of the adolescent girl					
literate	100%	172 (80%)	8 (3.72%)	35 (16.27%)	
Educational Status of the adolescent mother					
Illiterate	5.58%	12 (5.58%)	0	0	0.125
literate	94.41%	150 (69.76%)	13 (6.46%)	40 (18.60%)	
Class of adolescent girls					
7 th	11.68%	23 (10.69%)	2 (0.93%)	0	0.010*
8 th	25.70%	40 (18.60%)	1 (0.46%)	14 (6.51%)	
9 th	39.71%	74 (34.41%)	3 (1.39%)	8 (3.72%)	
10 th	23.36%	45 (20.93%)	2 (0.93%)	3 (1.39%)	
Prior knowledge of menstruation					
Present	76.74%	128 (59.53%)	5 (2.32%)	32 (14.88%)	0.0590*
Absent	23.25%	44 (20.46%)	3 (1.39%)	3 (1.39%)	

Data expressed in percentage “%” and “n” indicates the number of counts. Statistically significant was denoted as “*” and P- value fixed at 0.05

Table: 3 Practice of menstrual hygiene among the adolescent girls

Methods to clean the reused cloth	
With soap and water	92.3%
With water	7.69%





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Drying of the used cloth	
In sunlight	97.36%
Not in sunlight	2.63%
Method of disposal of cloth	
Burn it	29.41%
Throw it in with routine waste	55.88%
Others	14.7%
Method of disposal of sanitary pad	
Burn it	36.27%
Throw it in with routine waste	50.01%
Others	13.72%
Frequency of change of sanitary pads	
1 day	3.72%
2 -3 times day	73.48%
4 -5 times day	19.06%
No response	3.72%
Cleaning of the external genitalia	
Satisfactory (more than 2 times/day)	94.41%
Unsatisfactory (less than 2 times/day)	5.58%
Agents used to clean genitalia	
Only water	33.95%
Soap and water	61.86%
Water and antiseptic	4.18%

Data expressed in percentage “%”

Table: 4 Factor associated with cleaning of external genitalia

Variables used	%	Cleaning of external genitalia		P- value
		Satisfactory n= 203 (94.41%)	Unsatisfactory n= 12 (5.58%)	
Age in years				
<=12	6%	15 (6.97%)	4 (1.86%)	0.007*
13 -15	84%	175 (81.39%)	8 (3.72%)	
16-18	10%	13 (6.04%)	0	
Educational Status of the adolescent mother				
literate	94.41%	194 (90.23%)	8 (3.72%)	0.057*
Illiterate	5.58%	11 (5.11%)	2 (0.93%)	
Agents used to clean genitalia				
Only water	33.95%	71 (33.02%)	2 (0.93%)	0.051*
Soap and water	61.86%	128 (59.53%)	5 (2.32%)	
Water and antiseptic	4.18%	7 (3.25%)	2(0.93%)	
Prior knowledge of menstruation				
Present	76.74%	162 (75.34%)	3 (1.39%)	0.001*





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Absent	23.25%	44 (20.46%)	6 (2.79%)	
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Data expressed in percentage “%” and “n” indicates the number of counts. Statistically significant was denoted as “*” and P- value fixed at ≤ 0.05

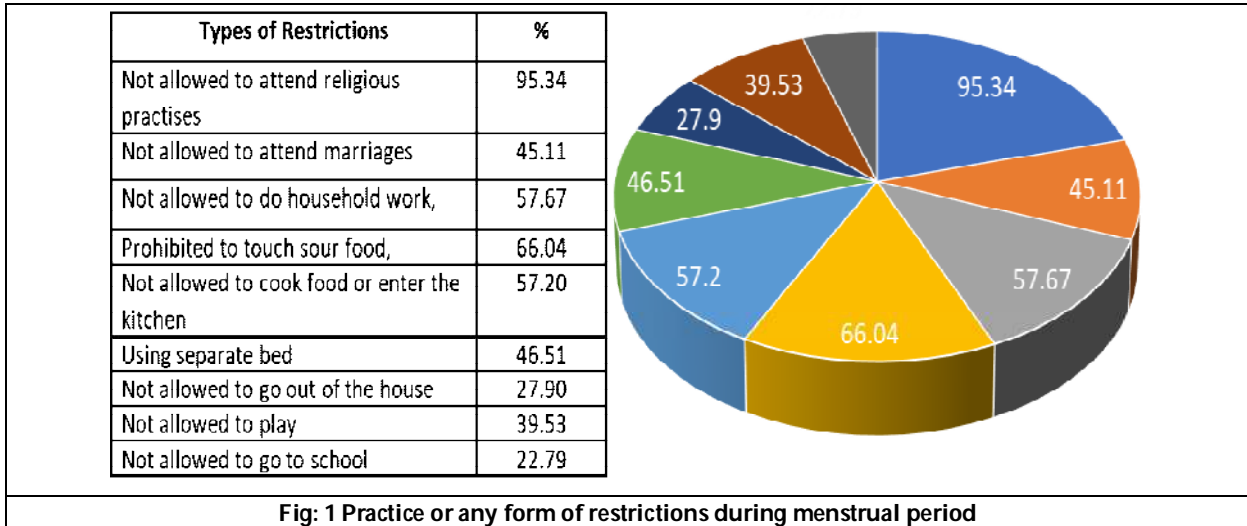


Fig: 1 Practice or any form of restrictions during menstrual period





Targeting Inflammation with Siddha Medicine: Docking Analysis of Sagadevi Nei against IL-6 and TNF- α

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ABSTRACT

Managing inflammation with considerable efficacy is a significant challenge due to the complex interplay of various factors. Proinflammatory cytokines play a critical role in the development of inflammation and neuropathic pain, which can lead to chronic inflammatory conditions and the progression of autoimmune diseases. During inflammation, cytokines are produced by adipocytes, and there is also a release of reactive oxygen species (ROS), further exacerbating the condition. *Sagadevi Nei*, a Siddha polyherbal formulation, has previously been investigated for its in-vitro nephroprotective activity. This study aims to assess the anti-inflammatory potential of *Sagadevi Nei* by focusing on its interaction with interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF- α) using molecular docking techniques. By retrieving relevant molecules from existing literature, researchers conducted a study to evaluate the binding efficacy and interactions of the phytochemical constituents of *Sagadevi Nei* with IL-6 and TNF- α . The findings revealed that the phytochemicals in *Sagadevi Nei* exhibit significant binding affinity and effective interactions with these proinflammatory cytokines. This suggests that *Sagadevi Nei* could potentially modulate inflammatory responses by targeting IL-6 and TNF- α , thereby offering a promising therapeutic approach for managing inflammation and related chronic conditions. The molecular docking study underscores the potential of this traditional formulation in contributing to anti-inflammatory therapy.

Keywords: Anti-inflammatory activity, IL6, Molecular Docking, Sagadevi Nei, TNF Alpha.



**Abarna and Manjari****INTRODUCTION**

The therapeutic properties and applications of herbs are widely known. In an environment where modern man has confronted the side effects and complexities of chemical drug usage, a return to nature and the use of natural and plant-based drugs occurs.[1] In an era dominated by technologies and hectic living, reconnecting with nature and embracing its therapeutic power has never been more important.[2] A traditional remedy that has been employed for several centuries to treat urinary tract conditions is *Sagadevi nei*. [3] This effective preparation was used in our research. *Sagadevi Nei* is scientifically proven to have anti-microbial activity.[4] As a natural biological reaction to chemical irritation, microbial pathogen infection, and tissue damage, inflammation occurs. The immune systems, both innate and adaptive, are involved in this biological process [5]. To eradicate foreign pathogens, Treat infection, and heal injured tissues, inflammation is triggered at a damaged site by immune cells migrating from blood vessels and releasing mediators. This is followed by the recruitment of inflammatory cells and the release of reactive oxygen species (ROS), reactive nitrogen species (RNS), and proinflammatory cytokines. Therefore, the primary purpose of inflammation is to strengthen the host defenses [6]. Normal inflammation often subsides quickly and on its own, but prolonged inflammation and abnormal resolution can lead to many chronic illnesses. Lately, molecular docking has become an essential part of in-silico drug development [7]. A common application of molecular docking is the study of protein and peptide interactions and binding affinities for biological activity [8]. This technique involves foreseeing the way a tiny molecule and a protein would interact at the atomic level. Siddha polyherbal formulation *Sagadevi Nei* consists of 11 ingredients that are proven scientifically to have anti-inflammatory, diuretic, antioxidant, and nephroprotective activity [9,10]. A total of 11 chemical constituents were derived from the 11 ingredients of *Sagadevi Nei* through a literature review and assessed for docking with Interleukin 6 (1N26) and TNF Alpha(2AZ5). [11-21]

MATERIALS AND METHODS

The Protein Data Bank (PDB) provided the 3D/ 2D structures of the target proteins 1N26 and 2AZ5 (IL6 and TNF Alpha), as depicted in Figure 1. The necessary lacking hydrogen atoms were added to the proteins during a cleanup procedure. The Autodock tool was utilized to assess the different lead molecule orientations of the target proteins. An examination of an interaction study was used to determine the optimal docking position. [22, 23]

METHODOLOGY

In order to assess phytochemicals against the target protein, docking calculations were performed. Important hydrogen atoms, Kollman unified atom type charges, and solvation parameters were added using AutoDock tools [24]. Using the Autogrid tool, affinity (grid) maps were created with $\times \times \text{Å}$ grid point dimensions and 0.375 Å spacing [24]. Distance-dependent dielectric functions and AutoDock parameter settings were used to calculate the van der Waals and electrostatic terms. The Lamarckian genetic algorithm (LGA) in conjunction with the Solis & Wets local search technique was used to carry out docking simulations [25]. The ligand molecules were initially assigned random orientations, locations, and torsions, with full freedom of motion for all rotatable torsions during docking. Every docking experiment had two runs, with each run ending when a maximum of 250,000 energy was used. The search procedure included a translational step of 0.2 Å, quaternion and torsion steps set at 5, and a population size of 150 [26, 27].

RESULTS AND DISCUSSION

In all, eleven major bioactive substances were isolated from the *Sagadevi Nei* as shown in Table 1 and Fig. 2. These compounds include β -sitosterol, glycyrrhizin, rutin, β -caryophyllene, piperine, gallic acid, picein, thymol, santalic acid, vetivenene, and linoleic acid, with molecular weights of 414.7, 822.9, 610.5, 204.35, 285.34, 170.12, 298.289,



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150.22, 234.33, 202.33, and 280.452 g/mol, respectively. The hydrogen bond donors for β -sitosterol, glycyrrhizin, rutin, gallic acid, picein, thymol, santalic acid, and linoleic acid are 1, 8, 10, 4, 4, 1, 1, and 1, respectively. The hydrogen bond acceptors for β -sitosterol, glycyrrhizin, rutin, piperine, gallic acid, picein, thymol, santalic acid, and linoleic acid are 1, 16, 16, 3, 5, 7, 1, 2, and 2, respectively. According to the data, the binding energies of the phytochemicals glycyrrhizin, rutin, β -caryophyllene, gallic acid, picein, thymol, santalic acid, vetivenene, linoleic acid, piperine, and β -sitosterol with 1N26 (IL-6) are -9.23, -11.97, -5.73, -5.87, -6.95, -5.44, -6.24, -6.93, -5.74, -7.27, and -7.83, respectively. These interactions occur with 3, 2, 1, 1, 5, 4, 3, 4, 3, 6, and 5 amino acid residues, respectively. The core active amino acid residues His70, Asp71, Ser72, Val91, Pro117, Ser119, Thr120, Pro121, Ser122, Thr124, and Thr125 of 1N26 (Interleukin 6) have at least one and up to five interactions. Notably, Pro121 interacts with a maximum of eight phytochemicals, as detailed in Tables 2 and 3. The obtained bioactive components glycyrrhizin, rutin, β -caryophyllene, gallic acid, picein, thymol, santalic acid, vetivenene, linoleic acid, piperine, and β -sitosterol with 2AZ5 (TNF Alpha) have binding energy -10.08, -11.52, -5.11, -4.47, -5.93, -3.76, -5.09, -5.67, -4.53, -6.02, -6.93 respectively and interactions of 3, 3, 3, 3, 3, 4, 4, 2, 3, 3 respectively. Also, 2AZ5 has interactions ranging from 2 to 5 with the active amino acids Leu57, Tyr59, Tyr119, Gly121, and Tyr151. The amino acids 59, 119, and 151 bind with a maximum of 10 phytochemical constituents (Table 4 and 5). The binding energies of the derived phytochemical constituents against IL6 (1N26) range from -11.97 kcal/mol to -5.44 kcal/mol, while against TNF-Alpha (2AZ5), they range from -11.52 to -3.76 kcal/mol (Table 2 and Table 4). Rutin exhibits the highest binding energy, -11.97 kcal/mol for IL6 and -11.52 kcal/mol for TNF-Alpha. Rutin has a log P value of -2.02, indicating its hydrophilic nature, which supports rapid dissolution and permeability, making it effective in detoxification [28]. Regarding interactions, the phytochemical components show 2-4 interactions with TNF-Alpha, with santalic acid and vetivenene having the most interactions. For IL6, the interactions range from 1 to 6, with piperine showing the highest number of interactions. These results indicate that the phytochemical constituents have strong binding energies and significant interactions with both targets, highlighting their potential anti-inflammatory properties. Therefore, *Sagadevi Nei* may be effectively used to treat inflammatory diseases.

CONCLUSION

The results indicate that the bio-active compounds Picein, Thymol, Santalic acid, Vetivenene, Linoleic acid, Piperine, β -caryophyllene, Glycyrrhizin, and β -sitosterol demonstrate significant binding affinity to the target proteins 1N26 and 2AZ5. These substances have interactions with the active amino acids at the areas of action of the proteins, indicating that *Sagadevi Nei* may have potential anti-inflammatory benefits.

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Table – 1: List of Phytochemical Constituents and Ligand Properties of the Compounds Selected for Docking Analysis

Herbs	Compound	Molar weight g/mol	Molecular Formula	H Bond Donor	H Bond Acceptor	Rotatable bonds	References
<i>Veronica cinerea</i>	β-sitosterol	414.7	C ₂₉ H ₅₀ O	1	1	6	7
<i>Glycyrrhiza glabra</i>	Glycyrrhizin	822.9	C ₄₂ H ₆₂ O ₁₆	8	16	7	8
<i>Hemidesmus indicus</i>	Rutin	610.5	C ₂₇ H ₃₀ O ₁₆	10	16	6	9
<i>Syzygium aromaticum</i>	β-caryophyllene	204.35	C ₁₅ H ₂₄	0	0	0	10
<i>Piper longum</i>	Piperine	285.34	C ₁₇ H ₁₉ NO ₃	0	3	3	11
<i>Nymphaea pubescens</i>	Gallic acid	170.12	C ₇ H ₆ O ₅	4	5	1	12
<i>Picrorhiza kurroa</i>	Picein	298.289	C ₁₄ H ₁₈ O ₇	4	7	4	13
<i>Plectranthus vettiveroides</i>	Thymol	150.221	C ₁₀ H ₁₄ O	1	1	1	14
<i>Santalum album</i>	Santalal acid	234.33	C ₁₅ H ₂₂ O ₂	1	2	4	15
<i>Vetiveria Zizanioides</i>	Vetivenene	202.33	C ₁₅ H ₂₄	0	0	0	16
<i>Ghee</i>	Linoleic acid	280.452	C ₁₈ H ₃₂ O ₂	1	2	14	17

Table – 2: Summary of the molecular docking studies of compounds against IL6 (Interleukin 6) (1N26)

Compounds	Est. Free Energy of Binding	Est. Inhibition Constant, Ki	Electrostatic Energy	Total Intermolec. Energy	Interact. Surface
β-sitosterol	-7.83 kcal/mol	1.83 uM	-0.05 kcal/mol	-9.07 kcal/mol	829.128
Glycyrrhizin	-9.23 kcal/mol	172.00 nM	-0.30 kcal/mol	-8.96 kcal/mol	973.537
Rutin	-11.97 kcal/mol	1.68 nM	-0.04 kcal/mol	-6.74 kcal/mol	877.191
β-caryophyllene	-5.73 kcal/mol	63.03 uM	-0.42 kcal/mol	-5.73 kcal/mol	510.406
Piperine	-7.27 kcal/mol	4.69 uM	-0.18 kcal/mol	-8.08 kcal/mol	636.702





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Gallic acid	-5.87 kcal/mol	49.45 uM	-0.41 kcal/mol	-5.40 kcal/mol	395.151
Picein	-6.95 kcal/mol	8.10 uM	-0.09 kcal/mol	-6.73 kcal/mol	542.617
Thymol	-5.44 kcal/mol	103.64 uM	-0.06 kcal/mol	-6.22 kcal/mol	444.491
Santalalic acid	-6.24 kcal/mol	26.69 uM	-0.38 kcal/mol	-7.29 kcal/mol	543.049
Vetivenene	-6.93 kcal/mol	8.29 uM	-0.00 kcal/mol	-7.23 kcal/mol	513.961
Linoleic acid	-5.74 kcal/mol	61.89 uM	-0.83 kcal/mol	-9.34 kcal/mol	790.45

Table – 3: Interaction of prime phytochemical constituent’s amino acid residues (His70, Asp71, Ser72, Val91, Pro117, Ser119, Thr120, Pro121, Ser122, Thr124, Thr125) with IL6 (Interleukin 6)

Compounds	Interaction	Amino acid Residues										
		46	69	70	72	90	93	119	122	123	124	
β-sitosterol	5	PRO	LEU	HIS	SER	LEU	VAL	SER	SER	LEU	THR	
Glycyrrhizin	3	PRO	LEU	SER	LEU	THR	SER	LEU	GLN			
Rutin	2	PRO	LEU	SER	VAL	GLU	SER	LEU				
β-caryophyllene	1	PRO	LEU	LYS	TYR	PHE						
Piperine	6	LEU	VAL	PRO	GLU	TRP	PRO	SER	THR	PRO	SER	
Gallic acid	1	PRO	LYS	GLN	TYR	PHE						
Picein	5	LEU	VAL	PRO	GLU	TRP	PRO	SER	THR	PRO	THR	
Thymol	4	VAL	PRO	GLU	TRP	PRO	SER	PRO	THR	VAL		
Santalalic acids	3	VAL	GLU	ARG	SER	PRO	THR					
Vetivenene	4	LEU	VAL	PRO	GLU	PRO	SER	PRO	THR			
Linoleic acid	3	LEU	VAL	THR	PRO	SER	LEU	LYS	TYR	PHE		

Table - 4 Summary of the molecular docking studies of compounds against TNF-alpha (2AZ5)

Compounds	Est. Free Energy of Binding	Est. Inhibition Constant, Ki	Electrostatic Energy	Total Intermolec. Energy	Interact. Surface
β-sitosterol	-6.93 kcal/mol	8.32 uM	-0.01 kcal/mol	-8.80 kcal/mol	662.244





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Glycyrrhizin	-10.08 kcal/mol	40.66 nM	-1.16 kcal/mol	-9.80 kcal/mol	800.96
Rutin	-11.52 kcal/mol	3.59 nM	-0.02 kcal/mol	-5.31 kcal/mol	580.046
β-caryophyllene	-5.11 kcal/mol	178.61 uM	-0.11 kcal/mol	-5.11 kcal/mol	395.96
Piperine	-6.02 kcal/mol	38.95 uM	-0.02 kcal/mol	-5.98 kcal/mol	458.503
Gallic acid	-4.47 kcal/mol	526.71 uM	-0.27 kcal/mol	-4.01 kcal/mol	334.523
Picein	-5.93 kcal/mol	44.73 uM	-0.07 kcal/mol	-5.93 kcal/mol	441.552
Thymol	-3.76 kcal/mol	1.76 mM	-0.06 kcal/mol	-4.38 kcal/mol	356.499
Santallic acid	-5.09 kcal/mol	185.18 uM	-0.10 kcal/mol	-5.82 kcal/mol	435.319
Vetivenene	-5.67 kcal/mol	69.85 uM	-0.24 kcal/mol	-5.97 kcal/mol	426.435
Linoleic acid	-4.53 kcal/mol	476.15 uM	-0.91 kcal/mol	-8.09 kcal/mol	

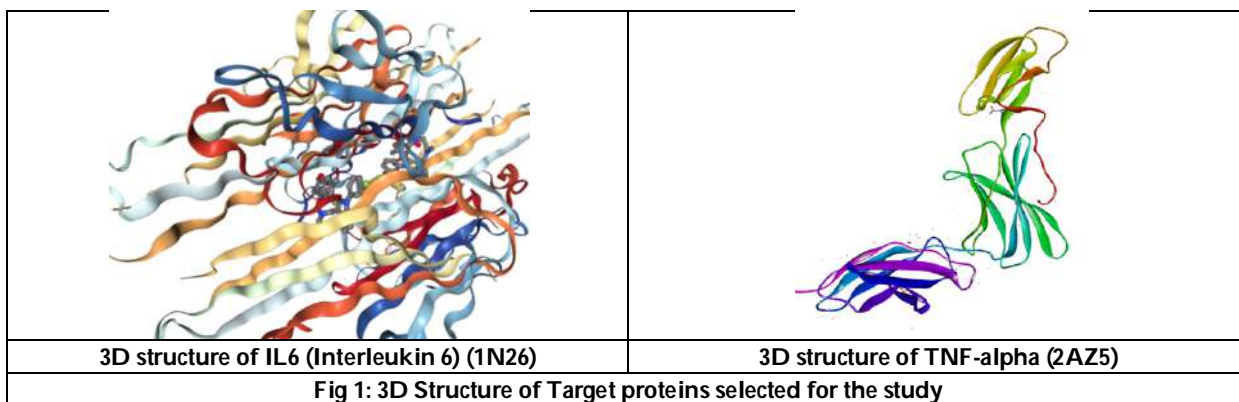
Table - 5: Interaction of prime phytochemical constituents' amino acid residues (Leu57, Tyr59, Tyr119, Gly121, and Tyr151) TNF-alpha (2AZ5)

Compounds	Interaction	Amino acid Residues							
		59	94	119	120	151	155		
β-sitosterol	3	TYR	LEU	TYR	LEU	TYR	ILE		
Glycyrrhizin	3	LEU	TYR	GLN	ALA	LYS	ILE	TYR	LEU
Rutin	3	TYR	TYR	TYR					
β-caryophyllene	3	TYR	GLN	TYR	TYR				
Piperine	3	LEU	TYR	TYR	ILE				
Gallic acid	3	TYR	GLN	TYR	TYR				
Picein	3	TYR	GLN	TYR	TYR				
Thymol	3	TYR	GLN	TYR	TYR				
Santallic acids	4	LEU	TYR	GLN	TYR	TYR			
Vetivenene	4	LEU	TYR	TYR	TYR				
Linoleic acid	2	GLN	ALA	ILE	TYR	TYR			





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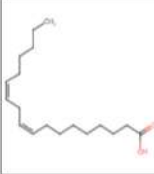
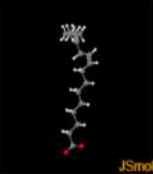


LIGAND	2D & 3D STRUCTURE		LIGAND	2D & 3D STRUCTURE	
β-sitosterol			Gallic acid		
Glycyrrhizin			Picein		
Rutin			Thymol		
β-caryophyllene			Santalnic acids		
Piperine			Vetivenene		





Abarna and Manjari

Linoleic acid	<div style="display: flex; justify-content: space-around;"><div><p>Ligand in 2D</p></div><div><p>Ligand in 3D</p></div></div>
Fig – 2: 2D and 3D Structure of Ligands Selected for the study	





Non-Steroidal Anti-Inflammatory Drug-Induced Peritonitis Secondary to Hollow Viscous Perforation - A Case Report

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ABSTRACT

A 32-year-old male patient came to a tertiary care hospital with complaints of pain in the abdomen for three days which was sudden in onset, continuous in nature, stabbing type with a past medication history of consumption of tablet diclofenac 50 milligram + paracetamol 325 milligram thrice daily for 10 days. During the abdominal examination on admission, it was observed to be distended and diffused tenderness was present. Ultrasonography of the abdomen showed hollow viscous perforation. On exploratory laparotomy, a 0.5 x 0.1-centimeter perforation was seen in the duodenum, which was repaired using an omental patch. The final diagnosis on discharge was made as peritonitis secondary to duodenal perforation.

Keywords: NSAID, Peritonitis, hollow viscous perforation, duodenal perforation, diclofenac

INTRODUCTION

Globally, Nonsteroidal anti-inflammatory drugs (NSAID) are the most widely consumed class of analgesics (Singh G and Triadafilopoulos G., 1999). NSAIDs are known for their anti-inflammatory, antipyretic, and analgesic properties, hence they are commonly used in primary healthcare (Al-Shidhani A, Al-Rawahi N *et al.*, 2015). Despite their effectiveness in pain relief, their use has been increasingly associated with gastroduodenal ulcers and other



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complications that may be attributable to the inhibition of prostaglandin synthesis (Cryer B and Feldman M.,1992;Gabriel SE and Jaakkimainen L,1991). Gastrointestinal (GI) complications caused by NSAIDs are well known in general; Predominantly upper GI complications are better documented compared to lower GI(Sostres C and Gargallo CJ, Lanas A.,2013).Hence, the same causing peritonitis secondary to hollow viscous perforation has not been well-documented (Singh G and Rosen Ramey D,1997). Hence, we report a case of a fixed drug combination of diclofenac and paracetamol-induced peritonitis secondary to hollow viscous perforation.

CASE

A 32-year-old male patient came to the emergency department with complaints of pain in the abdomen for three days which was sudden in onset, continuous in nature, stabbing type, and non-radiating. The patient was a smoker for seven years and an occasional alcoholic. He was a construction worker by profession and had given a history of trauma in the left forearm 24 days back, for which symptomatic management was provided at a government hospital and was started on tab. diclofenac 50 mg + paracetamol 325 mg thrice daily for 10 days. The patient did not give a history of consumption of any other medication and had no other comorbid conditions. During the abdominal examination on admission, it was observed to be distended, rigidity was more over the upper abdomen and diffused tenderness was present. Ultrasonography of the abdomen showed hollow viscous perforation. All the laboratory parameters were normal, except for the elevated Lipase levels (115U/L). Based on the above findings and patient's medical history, the provisional diagnosis was made as peritonitis secondary to hollow viscous perforation. The patient underwent an exploratory laparotomy under general anaesthesia with Graham's omentoplasty on an emergency basis. Thick plaques were present on the serosal surface of the duodenum and pyloric parts. Multiple collections of pus were present at the right and left iliac fossa (800cc). A perforation measuring 0.5 x 0.1 cm was observed in the anterior wall of the first segment of the duodenum. This perforation was fixed by using an omental patch. Multiple peritoneal washes were administered and bilateral drains were inserted. Postoperatively, the output was monitored and he was managed with the following medications which were administered as injections: Cefoperazone + Sulbactam 1.5gm, Metronidazole 500 mg, Paracetamol 1gm, and Pantoprazole 40mg for 7 days. The postoperative period was uneventful. The final diagnosis on discharge was made as peritonitis secondary to duodenal perforation. On discharge, the patient's vitals were stable. The sutures were intact, the wound was healthy and the patient was well tolerated orally. Antibiotics and analgesics were stopped and capsule Tramadol 50mg was started on an SOS basis.

DISCUSSION

This case describes a probable association between peritonitis secondary to duodenal hollow viscous perforation and diclofenac ingestion when consumed for a period of 10 days. NSAIDs are known to reduce inflammation associated with musculoskeletal conditions, hence frequently administered for low back pain, osteoarthritis, musculoskeletal injury, high-grade fever etc (Al-Shidhani A, Al-Rawahi *Net al.*,2015).They possess numerous medical benefits, and concurrently well-documented gastrointestinal adverse effects are available (from minor dyspepsia to major ulcers) (Al-Shidhani A, Al-Rawahi *Net al.*,2015;Gor AP and Saksena M.,2011;Chandwani HSet *al.*,2009). A similar probable association of peritonitis with diclofenac was reported in 2009, in which a female patient developed perforated peritonitis after nine days of treatment with 50mg, twice daily of diclofenac sodium (Chandwani HSet *al.*,2009). Ulcers usually manifest as necrotic or apoptotic injury to enterocytes, which can affect the deeper layers of the mucosa, leading to the loss of villi and the presence of an acute inflammatory cell infiltration. Enteropathy is the collective name for adverse drug reactions that occur in the duodenum, jejunum, and ileum (Boelsterli UA*et al.*,2012) Gastrointestinal disorders linked to NSAID use; range from dyspeptic symptoms, ulcerations, perforations, and in some cases hospitalization or death(Russell RI,2001;Forshaw MJet *al.*,2001).Multiple studies have shown that around two-thirds of patients, regardless of whether they used nonsteroidal anti-inflammatory drugs (NSAIDs) for a long-term period of more than three months or a short-term period of less than oneweek, experienced drug-induced lesions in their small intestine (Boelsterli UA*et al.*,2012).NSAIDs interfere with prostaglandin synthesis by inhibiting the cyclo-oxygenase pathway (Russell RI,2001), impair mucosal defence as the drug penetrates the protective mucous



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layers, and damages the epithelial lining cells. This further damage injures the cells, capillaries, and venules. Hence, the gastric secretions further contribute to pH-dependent local damaging effects (Ivey KJ, 1988). The aetiologies of peritonitis are infectious pathogens through perforated bowel, or irritating chemical substances, namely gastric acid from a perforated ulcer (Thirumalagiri VR, 2017). In the case described here, the patient was on multiple doses of diclofenac sodium orally for two weeks. The subsequent patient history, presenting signs and symptoms, and diagnostic test findings were unable to identify any etiology for duodenal perforations other than NSAID-induced enteropathy. Therefore, it was diagnosed as a case of Peritonitis secondary to diclofenac-induced multiple duodenal perforations. Multiple studies have reported NSAID-induced small bowel ulcers and erosions, mucosal haemorrhage, and erythema which were confirmed by endoscopic studies and colonoscopy, further confirming autopsy data. Studies also reported that 40% of rheumatic patients on NSAIDs experience these complications (Chandwani HSet al., 2009; Forshaw MJet al., 2001; Lanos Aet al., 1992; Kurahara Ket al., 2001; Graham DY et al., 2005). Among these NSAIDs, diclofenac is considered as an agent with comparatively less GI side effects. Studies state that 20% of patients on diclofenac for long-term management experience adverse events, of which 2% discontinued, primarily due to GI distress (Gor AP and Saksena M., 2011; Van Walsem A. et al., 2015). However, the occurrence of peritonitis secondary to hollow viscous perforation due to short-term consumption of NSAIDs is relatively rare and in this case, the patient had confirmed use for a duration of merely ten days. Aside from age, gender, prior ulcer history, smoking, alcohol intake, concurrent drug usage, and the presence of Helicobacter pylori infection have been identified as factors that can significantly contribute to gastrointestinal damage (Chandwani HSet al., 2009). In this case, the damage may have been further accelerated by the patient's gender and social history like smoking and alcoholism. Appropriately counselling patients to take the medication after meals and simultaneously administering mucosa-protective drugs such as PPIs, H₂ receptor antagonists and synthetic prostaglandin (eg: misoprostol) can attain prevention of unnecessary GI events due to NSAIDs. Further co-administration with drugs that can increase the risk of GI irritation such as anticoagulants and oral corticosteroids should be avoided. Moreover, NSAIDs should be avoided or administered at lower doses in patients with a previous history of GI ulcers secondary to NSAID use (Chandwani HSet al., 2009; Laine L., 2001). The Naranjo Scale was employed to evaluate the causality of the adverse drug reaction (ADR) (Naranjo CA et al., 1981). The assessment revealed the ADR to be 'probably' associated with diclofenac.

CONCLUSION

Over time, the use of NSAIDs has grown and is still growing. These could adversely affect any part of the gastrointestinal tract causing multiple ileal erosions and perforation, and hence NSAIDs should be used with caution.

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Measurement of Skull Size by using Computed Tomography for the Development of Bone Conduction Headset

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ABSTRACT

Bone conduction headsets have made tremendous technological advances, providing greater hearing experience by delivering sound via the skull bones directly into the inner ear of deaf patients and those who are having hearing loss issues. Optimal comfort and effectiveness in these devices are dependent on exact measurements of individual skull sizes. This paper investigates the history of skull size assessment methodologies, with an emphasis on the transformational impact of computed tomography (CT) in improving the design and personalization of bone conduction headsets. We illustrate the limits of older approaches while emphasizing the critical contributions of CT imaging. The paper explores CT concepts and uses in anatomical imaging, stressing its superior ability to provide precise and comprehensive skull measurements. The CT scanner measures the different parameters including length, width, circumferences and even temporal bone thickness. This will help the people suffering from hearing loss and help them to revive their hearing capability by development for better fitted BCIs with correct measurement via CT scan machine.

Keywords: Bone conduction headsets, Hearing loss, computed tomography, temporal bone thickness.





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INTRODUCTION

A Computed Tomography Scan, often known as a CT scan, is a medical imaging method that employs X-rays to generate detailed image of the internal structures within the body, such as bones, muscles, blood arteries, and organs. CT scans are also reasonably pleasant and speedy. Godfrey Hounsfield, a British engineer, created the first CT scanner in 1971. In 1979, Hounsfield received the Nobel Prize in Physiology or Medicine for his work on CT **scanning (Mohd. Waheed El Anwar et al.,2017)**. A Bone Conduction Implant (BCI) is a surgically implanted device that aids hearing loss by bypassing the outer and middle ear and stimulating the inner ear directly. People with conductive hearing loss, mixed hearing loss, and single-sided deafness are treated using BCI(Cheol Hyo Ku et al., 2019). It functions by transforming sound waves into vibrations that are communicated to the inner ear via the skull. These vibrations are subsequently sent to the brain, where they are processed as sound. Hearing Loss is the inability to hear sound in one or both ears. People with hearing loss account for 5.3% of the global population. Hearing loss is classified based on ear anatomy, type of hearing loss, illness severity, and audiogram configuration(Aaron R. Baker et al., 2016). When the hearing loss has been properly defined, the appropriate medical intervention can be allocated.

Classification of Hearing Loss

Based on cause

1. Conductive hearing loss: It is caused by an issue in the outer or middle ear that inhibits sound waves from reaching the inner ear. Earwax accumulation, infection, fluid in the middle ear, or a ruptured eardrum can all cause this sort of hearing loss.
2. Sensorineural hearing loss: This condition is caused by injury to the inner ear or the cochlea. This form of hearing loss is typically irreversible and cannot be treated with surgery or medicines.
3. Mixed hearing loss: It is the mix of conductive and sensorineural hearing
4. Based on severity:
5. Mild hearing loss: The least severe kind of hearing loss is mild hearing loss. In loud surroundings, people with this condition may have difficulties hearing subtle noises or conversations.
6. Moderate hearing loss: The person may have difficulties hearing quiet and medium noises. He/she may also struggle to interpret speech in loud situations.
7. Severe hearing loss: The person may struggle to hear medium and loud noises. He/she may also struggle to understand speech if they do not utilize hearing aids or other assistive technologies.
8. Profound hearing loss: The person might hear very little or nothing at all. Lip reading or sign language may be used to communicate. The design of the head set body controls the amount of contact and pressure between the head and the device, which is critical for sound transmission efficiency. As a result, bone conduction hearing aids should be designed to fit the head size of a certain demographic. Computed tomography imaging allows for the assessment of any skull bone structure and shape that cannot be measured physically(Cheol Hyo Ku et al., 2019). In this work, we assessed the head dimensions using several parameters.

Historical Perspectives

Bone conduction technology was initially developed in the early 1800s by the renowned scientist Giovanni Batista Morgagni, who noticed vibrations passing through the skull. But it wasn't until the 20th century and the invention of bone conduction hearing aids. And these findings translated into real-world uses. In order to help transmit sound, early devices were crude and frequently resembled headbands or clamps that pushed on the skull. Even with the advancements, it was still difficult to determine skull size accurately. Conventional techniques, which relied on calipers and uniform templates, could only approximate cranial measurements in a broad way. This restriction limited the general acceptance of early bone conduction devices in addition to impeding their effectiveness. With the introduction of computed tomography (CT) in the 1970s, the historical trajectory of skull size assessment underwent a sea change(Dong Su Jang et al., 2020). This was a revolutionary time since CT scans made it possible for researchers and developers to recreate skulls in three dimensions, going beyond simple measurements to explore the detailed features of individual skulls. The capacity to accurately measure and examine cranial features opened the door to





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customized designs that addressed the natural differences in the morphology of the skull between people (Aaron R. Baker et al., 2016). The historical progression from simple bone conduction aids to the complex headsets of today is closely associated with the incorporation of CT-based estimations of skull size. The combination of computed tomography and bone conduction technologies marks a significant turning point in this historical narrative.

Computed tomography for skull size measurement

The development of computed tomography (CT) has completely changed the field of medical imaging by providing detailed and accurate anatomical evaluations.

1. **Principles of Computed Tomography** Based on the ideas of X-ray imaging, computed tomography is unique in that it can provide cross-sectional image of the body. Through the rotation of an X-ray source around the subject and the use of detectors to monitor the radiation that is delivered, CT scans provide comprehensive, three-dimensional images of interior structures.
2. **Benefits Compared to Conventional Approaches** The depth three-dimensional morphology of the skull is frequently difficult to capture using conventional methods, which results in inaccurate measurements. On the other hand, a CT scan offers a detailed image of the interior and exterior characteristics of the skull, making it possible to measure the volume, breadth, and length of the structure precisely. This precision is crucial for the unique design factors that are vital for the development of bone conduction headsets.

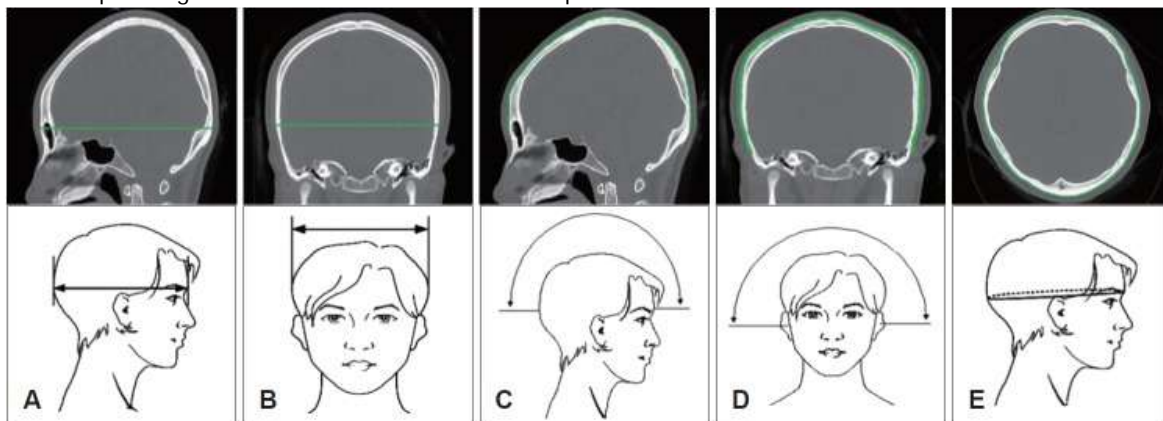


Figure 1: head length (A), head width (B), sagittal arc (C), bitragion arc (D), head circumference (E)

3. **Customized Imaging procedures** by customizing CT scans to target certain regions of interest, researchers may ensure precise data that are pertinent to the construction of bone conduction headsets. Furthermore, improvements in imaging methods, including multi-detector CT and high-resolution CT, enhance the capacity to catch minute features and provide a more complex image of cranial morphology.

4. Accuracy in Customized Headset Design The combination of CT scan and skull size estimation is consistent with the trend toward customized audio technologies. Individual differences in the structure of the skull can have a big impact on how comfortable and effective bone conduction headsets are. With the degree of accuracy made possible by CT, designers can now take these variances into consideration and create headsets that flawlessly fit each user's individual skull shape, including case studies and instances where CT-derived measurements of skull size have significantly advanced the state-of-the-art in customized audio technology.

Applications in Bone Conduction Headset Development

Computed tomography (CT) is becoming a vital tool for measuring skull size, and its uses go well beyond simple medical diagnoses. When it comes to improving the overall user experience, maximizing comfort, and fine-tuning design parameters, CT-derived data is essential to the development of bone conduction headsets.

1. **Customization accuracy** CT scans offer a thorough picture of a person's skull morphology. The precise length, breadth, and volume measurements allow for the production of headset components that are tailored to precisely suit each user's unique skull characteristics (Hyun-Ja Lee et al., 2008).





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2. **Customized Transducer Positioning** In bone conduction headsets, the positioning of transducers has a significant impact on the effectiveness of sound transmission. Designers can see the interior features of the skull via CT scans, which helps them determine the best places to put transducers depending on each person's anatomy (Panagiotis A Dimitriadis et al., 2017). With this focused approach, acoustic leakage is reduced, sound quality is improved, and an immersive audio experience is enhanced.
3. **Evaluation of Temporal Bone Characteristics** Bone conduction technology performance is highly influenced by the morphology of the temporal bone. A thorough analysis of the temporal bone structure is made possible by CT imaging, which makes it easier to spot differences that can affect headset design (Mark C Flynn et al., 2012). This information enables designers to modify their strategy, taking individual variances into consideration and maximizing the headset's compatibility with a variety of temporal bone properties.
4. **Effect on Headset Comfort** Beyond the technical elements, bone conduction headset ergonomic design is influenced by CT-derived skull size measurements. Designers can address pressure spots and create headbands or support structures that decrease pain during continuous usage by taking into account each person's unique skull characteristics (Gaeun Kim et al., 2017).
5. **Case Research and Practical Uses** Several case studies and practical applications demonstrate the effectiveness of CT-derived skull size measurements in bone conduction headset creation. By analyzing these cases, we may get insight into how CT technology has helped solve design problems, enhance user experience, and advance audio technology. The aforementioned applications highlight the revolutionary influence of CT in molding the forthcoming of customized and superior audio solutions.

Comparison differences between Conventional methods and CT scan for measurements

1. **Precision and Accuracy** traditional methods of measuring skull size, such as calipers and tape measures, may lack the precision required for intricate anatomical details, leading to potential inaccuracies. Whereas, CT provides high-resolution, three-dimensional images, offering unparalleled precision in skull size measurements (Xu Tian et al., 2020). The detailed cross-sectional images enable precise assessments of bone structures, minimizing measurement errors.
2. **Time Efficiency** Traditional measurements can be time-consuming, especially when attempting to capture intricate details manually. Whereas, CT scans provide rapid acquisition of detailed images, significantly reducing the time required for skull size assessment. This efficiency is crucial for timely and effective development of personalized bone conduction devices.
3. **Personalization Potential** Conventional methods may offer limited options for personalization, relying on basic external measurements. Whereas, CT facilitates highly personalized design by capturing detailed anatomical features, enabling the development of bone conduction devices that precisely conform to the individual's skull structure.

Challenges and Future Directions

Although the use of computed tomography (CT) has unquestionably transformed the determination of skull size for the creation of bone conduction headsets, there are still difficulties in integrating this technology. It is critical to address these issues as we go through the current environment and set the path for future developments that will strengthen the relationship between audio technology and CT imaging.

1. **Ethical Concerns** Patient permission, privacy, and data security are among the ethical issues raised by the collection and use of CT data for the creation of customized audio devices. It is crucial to strike a balance between innovation and morality, which calls for precise rules and strong safeguards to protect user privacy and data integrity (M E Zernotti et al., 2019).
2. **Radiation Exposure Concerns** Although at very low doses, CT imaging exposes patients to ionizing radiation. Although radiation doses have decreased due to advances in CT technology, there are still worries about repetitive exposure, particularly in applications that need frequent measurements or longitudinal research.
3. **Handling Variability in Soft Tissues** Computed tomography (CT) is a valuable tool for identifying bone structures, but it can have difficulties when it comes to precisely defining soft tissues. The accuracy of skull size measurements can be affected by variations in soft tissue properties, particularly in areas that are crucial for the





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positioning of headsets(Farid Alzhrani,2019). Suggestions for future work include investigating supplementary imaging modalities or image processing approaches to improve measurement accuracy and soft tissue visibility.

4. **Integration with Artificial Intelligence (AI)** The use of AI in the development of bone conduction headsets will be crucial for the future of skull size measuring. Large-scale CT dataset analysis may be streamlined by AI algorithms, which can also automate measurements and spot subtle patterns that would be missed by human inspection. Research and development procedures might be sped up by this integration, which would also improve the accuracy of measurement results.
5. **Multidisciplinary Collaboration** Teams comprising radiologists, audiologists, engineers, and ethicists must work together successfully to integrate CT imaging into the creation of bone conduction headsets. It is recommended that future initiatives prioritize multidisciplinary techniques, communication, and information exchange in order to handle difficulties from several angles and improve the overall caliber of research findings(Timo Gerdes et al., 2016).

CONCLUSION

The combination of computed tomography (CT) imaging and skull size assessment in the field of bone conduction headset development is a testament to the revolutionary potential of technology in defining the future of individualized audio experiences. The impact of CT becomes clear as we follow its historical development from crude bone conduction aids to customized, high-tech headsets. By providing a three-dimensional window into the intricacies of each individual's cranial anatomy, the accuracy provided by CT in the assessment of skull size has advanced the field beyond the limitations of conventional approaches. To guarantee the appropriate and fair integration of CT technology, obstacles like radiation exposure concerns, ethical issues, and the requirement for standardization must be overcome. Prospective paths for the future include integrating artificial intelligence, collaborating across disciplines, and going beyond skull size to examine wider cranial traits. The discipline has the potential to improve not just how we estimate skull size but also how we understand and work with the complex subtleties of human anatomy in the years to come. The combination of CT and audio technologies redefines the user experience for bone conduction headsets by providing previously unattainable levels of personalization, comfort, and audio fidelity. As we go into the future, the trip from the foundations of history to the vanguard of innovation is a monument to the perseverance of scientific research and the limitless capacity of technology to influence our perceptions of and interactions with the auditory world.

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Air Kerma Strength Measurement of Cobalt - 60 Source using Well Type vs Farmer chamber in Saginova High Dose Rate Brachytherapy

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ABSTRACT

The purpose of this study is to measure the air kerma strength (AKS) using well type chamber and Farmer chamber with cylindrical phantom for cobalt-60 source and compare with the manufacturer data and available literature. An applicator placed inside the source holder of the well type chamber and Farmer chamber with cylindrical phantom. The chamber was connected with electrometer. The dwell position was activated at five mm intervals with dwell time 60 seconds in the treatment planning system and the plan was executed in the HDR unit. The maximum current was measured in nanoampere (nA) at particular dwell position in well type chamber and the readings were tabulated. In Farmer chamber, the electric charge measured at particular maximum current dwell position. The readings were measure in different volts and tabulated. The correction factors were applied to calculate the AKS for both chambers. The percentage deviation between the manufacture and measured data is -1.34% in well type chamber and -2.86 % in Farmer chamber respectively. In worldwide, well type chamber is used for AKS measurement in HDR brachytherapy sources, but the Farmer chamber along with cylindrical phantom is also capable for AKS measurement for HDR brachytherapy sources.

Keywords: Well type chamber, Farmer type chamber, cylindrical phantom, Co-60 source.





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INTRODUCTION

The goal of radiotherapy is to maximum dose to the tumor and minimum dose to normal tissues for cancer treatment. Radiotherapy divides into external beam radiotherapy and brachytherapy. In 1898, Madam Marie curie was discovered the radium source and it was the milestone for brachytherapy. Brachytherapy (BT) is using sealed radioactive source placed inside the tumor. Radioactive sources such as Radium-226 (Ra-226), Cesium-137 (Cs-137), Iridium-192 (Ir-192) and Cobalt-60 (Co-60) and Iodine-125 (I-125) are used for BT treatment due to their rapid dose fall off to achieve the goal of radiotherapy. BT is divided into dose rate such as low dose rate (0.4-2 Gy/hr) (LDR), medium dose rate (2-12 Gy/hr) (MDR) and high dose rate (greater than 12 Gy/hr) (HDR). Ir-192 source is common source in HDR BT for its specific activity, easy availability. But, it needs to be change three months once because of its lesser half-life (73.8 days). Nowadays, miniaturized Co -60 source availability increases and replace the Ir-192 source for its longer half-life (5.26 years). [1,2] Quality assurance plays a vital role in radiotherapy for patient treatment. The air kerma strength (AKS) measurement is recommended QA for the source strength calibration in BT and the tolerance is within $\pm 3\%$ of manufacturer data. Air kerma strength is defined as the product of the air kerma rate at calibrate distanced, in free space from the source centre along the perpendicular direction and square of the distance. {AKS = Reference air kerma rate X (distance)² }. [3-6] Goetsch et al. created the standard AKS calibration for Ir -192 HDR brachytherapy sources at the University of Wisconsin Accredited Dosimetry Calibration Laboratory (UWADCL) in 1992. This calibration procedure is known as the seven-distance measurement approach, using a graphite wall Farmer chamber to measure the AKS at seven distances in air. Direct or indirect approaches can also be used to determine the AKS of a high-dose rate (HDR) brachytherapy source. [7] Well-type ionization chambers were used for indirect measurements, while a Farmer chamber and the seven-distance approach can be employed for direct measurements of AKS. The German society of Medical Physics (DGMP) report number 13 recommends the Farmer chamber along with cylindrical phantom (Krieger phantom) for the purpose of AKS measurement in HDR brachytherapy. [8] The aim of this study is to measure the air kerma strength using Farmer chamber with cylindrical phantom and well type chamber for saginova cobalt-60 source HDR brachytherapy and compare with the manufacturer data and available literature.

MATERIALS AND METHODS

The study was conducted in Saginova HDR brachytherapy equipped with cobalt-60 source. The unit has 25 channels to deliver the treatment and the source dimension is 3.5mm (L) X 1 mm (D). The treatment planning system is Sagiplan (Version 2.0.2). The treatment execution in this unit is divided into three parts. They are treatment control panel (TCP), treatment control console (TCC) and treatment delivery unit (TDU). Before AKS measurement, the daily QA was performed by qualified medical physicist.

Well type chamber measurement:

Figure 1 show the experimental set up of well type chamber measurement. Well type chamber (PTW source check, Germany) consists of an aluminum wall ion chamber filled with argon gas under high pressure. The collection potential applied to the chamber was about 300 V. A source holder is used to hold the applicator to reproduce the source geometry in relation to the surrounding chamber walls. The energy dependence of the chamber arises from absorption and scattering of the photons and secondary electrons in the chamber walls and the gas. Besides this intrinsic energy dependence, oblique filtration through the source encapsulation affects the chamber response. An applicator placed inside the source holder of the well type chamber. The chamber was connected with electrometer (PTW, Romeo). The dwell position was activated at five mm intervals with dwell time 60 seconds in the treatment planning system and the plan was executed through the HDR unit. The maximum current was measured in nanoampere (nA) at particular dwell position (sweet spot) through the electrometer and the readings were tabulated. The maximum current at a particular dwell position was repeated three times and average reading was noted. The air kerma strength was calculated using the below mentioned formula:

$$AKS = M \times N_{RAKR} \times K \times T, P$$

(Eqn 1)





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AKS - Air kerma strength in cGy cm²/hr

M - Average meter reading in nA/min

N_{RAKR} - Calibration factor in Gy.m² h⁻¹A⁻¹(9.669X10⁵) for chamber (Co-60 source)

K_{T,P} - Temperature, Pressure correction factor

$$K_{T,P} = (273.2 + T / 273.2 + T_0) \times (P_0 / P) \quad (\text{Eqn 2})$$

T, P = Room temperature and pressure

T₀, P₀ = Reference temperature and pressure (T₀ = 20 degree ; P₀ = 1013.2 mbar)

Cylindrical phantom with farmer type chamber:

Figure 2 shows the Farmer chamber with cylindrical phantom experimental set up. A cylindrical phantom is made up of tissue equivalent material along with Farmer chamber is used for measurement. The chemical composition of the phantom is C₅H₈O₂ and density is 1.16-1.20 g/cm³ respectively. It has a total diameter of 200mm and height of 120 mm. Four holes were drilled equidistant from each other at 0, 90, 180 and 270 degrees at the periphery of the phantom. These holes have a diameter of 13 mm for holding the ionization chamber. A central hole or channel having a diameter of 4mm was drilled for placing the applicator and acts as the source holder. The distance between the holes from the central channel is 80 mm and is actually a compromise between the high dose gradient close to the source and the signal level fall off with distance. The sensitive volume of the chamber and centre of the active source were maintained at the same level and parallel to each other. An applicator was inserted into the central hole and the Farmer chamber (PTW, farmer type chamber) placed inside the PMMA cylindrical phantom. The chamber was connected with electrometer and selected 400 V to measure the maximum current. The dwell position was programmed at dwell position of five mm and dwell time 60 seconds. The maximum current reading was noted at a particular dwell position. The measurement was changed from current mode to charge mode in the electrometer. The particular maximum current dwell position was activated 60 seconds and executed three times for reproducibility. The charge was measured in nanocolomb (nC) at particular maximum current dwell position and tabulated at 400 V, 200 V and -400V for the ion recombination correction factor (Kion) and polarity correction factor (Ks).

$$K_{ion} = \frac{\{(V_2/V_1)^2 - 1\}}{\{(V_2/V_1)^2 - (M_2/M_1)} \quad (\text{eqn 3})$$

$$K_s = \frac{(M_1 + M_3)}{2M_3} \quad (\text{eqn 4})$$

M₁ = average meter reading at 400 V

M₂ = average meter reading at 200V

M₃ = average meter reading at -400V

The below correction factors are taken from DGMP recommendation for AKS calculation (8)

$$AKS = (1 - g_a)^{-1} \times \left\{ \frac{(\mu_{en}/\rho)_a}{(\mu_{en}/\rho)_w} \right\} \times K_w \times K_a \times N_w \times K_{z,p} \times K_r \times X$$

$$K_{T,P} \times K_{ion} \times K_{pol} \times M_1 \times 60 \quad (\text{Eqn 5})$$

g_a, g_w = Relative bremsstrahlung losses in air or water = 0.1 for Ir 192 radiation

g_a = g_w = 0.1 % (assumed same value for Co-60 point source)

$$\frac{(\mu_{en}/\rho)_a}{(\mu_{en}/\rho)_w} = 0.9276$$

{(μ_{en}/ρ)_a = Mass energy absorption coefficient in air; (μ_{en}/ρ)_w = Mass energy absorption coefficient in water}

K_w = field perturbation correction of water in plexi class surrounding = 1.00

K_a = for correction factor for source quality deviation from Co-60

N_w = calibration factor in water (5.404X10⁷Gy/C)

K_{z,p} = Geometry factor for cylindrical phantom = 1.187

K_r = correction of distance from 8 cm to 1 cm accordance with inverse square law. (K_r = (8/1)² = 64)

K_{T, P} = Temperature pressure correction factor

K_{ion} = Ion recombination correction factor

K_{pol} = polarity correction factor

M₁ = average meter readings



**Revathy and Shanmukhappa B Kaginelli****Statistical analysis**

Descriptive statistics was done using Microsoft excel software.

RESULTS

Table 1 shows the well type chamber measurement. The maximum current is at 10th dwell position in the applicator and the maximum current is 19.32 nA. Table 2 shows the Farmer chamber measurement and maximum current is 13.52 nA at first dwell position. Table 3 shows the measurement of charges in nC at 400V, 200V and -400V for ion recombination and saturation correction factors. Table 4 explains the percentage deviation between the manufacturer data and measured data of both chambers. The manufacturer AKS is 20810 cGy.cm²/hr, the measured AKS in well type chamber is 20531 cGy.cm²/hr and Farmer chamber with cylindrical phantom is 20231 cGy.cm²/hr respectively. The percentage deviation between the manufacture and measured is -1.34% in well type chamber and -2.86 % in Farmer chamber respectively.

DISCUSSION

The air kerma strength is one of essential part of the QA in BT. The primary objective of this study was to evaluate the feasibility of use of well type chamber and Farmer chamber for determination of air kerma strength of Co 60 HDR brachytherapy source. Table 5 explains the comparison of different literature of AKS measurement for well type chamber and Farmer chamber with cylindrical phantom using Ir-192 and Co-60 sources. Batlas et al, Patel et al and Bondel et al were measured AKS using both chambers in Ir-192 source.[9-11]Azhari et al was measured AKS using both chambers in Ir-192 and Co-60 sources.[12]Emmanuel et al was measured two different AKS Co-60 sources using both chambers.[13] For Ir-192 source, the percentage deviation was observed the well type chamber (range from -2.04% to 1.1%) compare to Farmer chamber (range from -2.2% to 0.62%) in the literature. Azhari et al have performed AKS measurement for both Ir-192 and Co-60 sources according to three international protocols with different methods. The measurements showed deviations from the manufacturer data about 1.1% for Ir-192 source and 1.2% to -2.2% for Co-60 source in both chambers. Emmanuel et al measured the AKS using PTW well type chamber, HDR 1000 plus chamber and Farmer chamber with cylindrical phantom for two different AKS Co-60 sources. They have showed that the percentage of deviation was -2.8% and -1.06% in PTW well type chamber, -1.97% and 0.65% in HDR1000 plus well type chamber and 1% and 2.4% in Farmer chamber respectively. In our study, we found -1.34% variation in well type chamber and -2.86% variation in farmer type chamber respectively.

Apart from AKS measurement, some of the studies explained about the characteristics and performance of both chambers in Ir-192 and Co-60 sources. Sathyan et al measured the different physical properties of BDS1000 (Rosalina, India) well type chamber and compared with HDR1000 plus (Standard imaging, USA) and BTC/3007 (Capintec USA) well type chambers. He was measured the nominal response of different well type chambers and found the values were 1.636 nA/AKS for BDS1000, 1.972 nA/AKS for HDR 1000 plus and 13.87nA/AKS for BTC/3007 respectively. [14] We observed that 1.930 nA/AKS nominal response in PTW source check well type chamber in our study. Andrassay et al have stated in their study that QA instrumentation used for Ir-192 source is also compatible with Co-60 source. Both chambers can be calibrated for both the sources, with traceability to the appropriate primary standards. [15]Kambauwa JD explained in his study about the well type chamber and Farmer chamber with cylindrical phantom. He concluded in his study, the Farmer chamber with cylindrical phantom can be used for calibration of HDR BT and routine measurements of QA in clinical set up of BT.[16] In our study, the maximum current is measured at different positions in both chambers (well type chamber at 50 mm and farmer type chamber with cylindrical phantom at 5 mm from the tip of the applicator) and observed current values are low in the cylindrical phantom with farmer type chamber compared to well type chamber because of the chamber volume and the position of the applicator. Well type chamber has larger volume (approx. 200 cm³) in 4 π geometry compare to farmer type chamber volume (0.6 cm³). Well type chamber is calibrated in air (NRAKR) and Farmer chamber is calibrated in water (ND,W). The uncertainty factors are more in Farmer chamber compare to well type chamber. The strength of



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this study is to measure the AKS using both well type chamber and Farmer chamber in Co-60 source of saginova HDR brachytherapy. The limitation of the study is only focus on two methods well type chamber (commonly used in brachytherapy calibration) and Farmer chamber with cylindrical phantom DGMP recommendation); other techniques were not measured because to various challenges. The most widely used dosimeters in HDR brachytherapy calibration are well-type chambers. Hence, most of the physicist preferred well type chamber for calibration of HDR sources. But, the Farmer chamber with cylindrical phantom is also capable to calibrate the HDR sources and found within the tolerance limits from the manufacturer data and compared with available literature.

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Table 1: Well Type Chamber Measurement

Dwell Position	Distance(mm)	Current (nanoAmphere)		
		M1	M2	M3
1	5	15.53	15.54	15.55
2	10	16.46	16.47	16.47
3	15	17.24	17.25	17.25
4	20	17.85	17.87	17.86
5	25	18.33	18.35	18.35
6	30	18.70	18.70	18.71
7	35	18.97	18.97	18.98
8	40	19.16	19.17	19.17
9	45	19.27	19.28	19.28
10	50	19.31	19.32	19.32
11	55	19.28	19.28	19.29
12	60	19.17	19.16	19.18

Table 2: Farmer chamber Measurement for Maximum Current

Dwell Position	Distance(mm)	Current (nanoAmphere)		
		M1	M2	M3
1	5	13.50	13.52	13.52
2	10	13.40	13.40	13.41
3	15	13.20	13.21	13.20
4	20	12.85	12.84	12.85
5	25	12.45	12.44	12.46

Table 3: Charge Collection Measurement of Farmer chamber at Different Volts

Dwell Position	Distance(mm)	Voltage (V)	Charge nanoColoumb)		
			1	2	3
1	5	+400(M1)	0.812	0.811	0.812
		+200(M2)	0.811	0.811	0.811
		-400(M3)	0.816	0.815	0.816

Table 4: Comparison between both Chambers

	Well type chamber	Farmer type chamber
Volume in cc	200	0.6
Maximum current at dwell position	10	1
Manufacturer Air kerma strength (cGy.cm ² /hr)	20810	20810
Measured Air kerma strength (cGy.cm ² /hr)	20531	20231
Percentage of deviation	-1.34%	-2.86%

Table 5: Comparison with Literature

Literature	Source	Percentage deviation from manufacturer data	
		Well type chamber	Farmer type chamber with cylindrical phantom
Baltas et al(9) (1999)	Ir-192	0.11	0.44
Patel et al(10) (2005)	Ir-192	-2.04	-1.48
Bondel et al(11)	Ir-192	0.21	0.62





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(2014)			
Azhari et al(12)	Ir-192	1.10	1.1
(2012)	Co-60	1.2	-2.2
Emmanuel et al(13)	Co-60 (i)	-2.80	-1.97
(2019)	Co-60(ii)	-1.06	0.65
Present study	Co-60	-1.34	-2.86
(2023)			



Figure:1 Well type chamber experimental setup

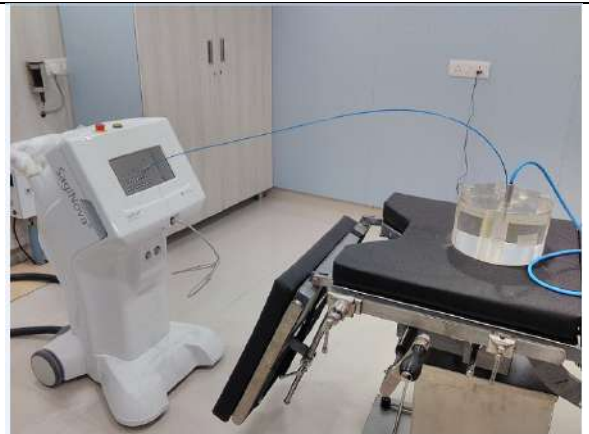


Figure:2 Farmer chamber with cylindrical phantom experimental setup





Artificial Intelligence in Smart Agriculture : A Short Review

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ABSTRACT

In this review we explore the potential, for intelligence (AI) to transform agriculture and meet the demands of a growing population. The focus is on three areas; analytics, advancements in agricultural robotics and precision farming practices including crop surveillance. These are identified as areas where AI could make a difference. Additionally the assessment highlights the Internet of Things (IoT) as a technology with potential for future applications, in agriculture. In spite of these obstacles, considerable advancements have been made recently in the creation of agricultural robots for diverse purposes. The analysis highlights the potential developments and bright future of AI in agriculture, while acknowledging the challenges of applying research findings to actual farms.

Keywords: Artificial Intelligence (AI), IOT, Precision farming, Smart agriculture, Robotics

INTRODUCTION

The significance of agriculture to the worldwide economy is growing as a result of population growth-driven increases in food consumption. Many sectors are changing as a result of machine learning (AI), one of the technologies that is developing the fastest right now [1]. Aware of its potential, scientists and academics are investigating how artificial intelligence (AI) and the Internet of Things (IoT) may be integrated with "smart farming" to enable farmers [2]. AI in agriculture has the potential to improve crop protection tactics, fertilizer usage, and seed creation, ultimately boosting agricultural profitability and the country's economy [3]. Three general categories can be used to group AI's contributions to agriculture: agricultural robotics, analytics for prediction, precision farming and



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crop monitoring [4]. One of the biggest issues at the moment is agriculture, which is crucial for any nation. Approximately 820 million people worldwide are estimated to be undernourished [5]. Furthermore, 70% more food needs to be produced because the world's population is predicted to reach 9.1 billion in 2050. In order to prevent around 370 million people from becoming hungry in 2050, further investment in agriculture will be required in addition to the predicted amounts. Furthermore, there is expected to be an increasing disparity between the amount of water that is accessible and the growing demand for water; by 2025, more than three billion people are expected to be under water stress [6].

Precision farming

In the coming years, precision farming is gaining significant traction within the agricultural field. This approach integrates artificial intelligence and data-driven insights to revolutionize traditional methods. By enabling a more targeted approach to resource management, precision farming plays an increasingly crucial role in modern farming, advancing sustainability and delivering numerous efficiency gains [7].

Focusing on benefits for the environment

- Minimizing water waste, reducing reliance on chemical fertilizers and pesticides, and promoting soil health. This not only benefits crop yields but also contributes to a more sustainable food system for future generations [8].

Focusing on economic benefits for farmers

- leading to increased profitability for farmers. With precise data on crop health and resource needs, farmers can optimize their inputs, minimize waste and maximize their return on investment [9].

Focusing on technological advancements

- Advancements in sensor technology, cloud computing, and machine learning continue to evolve. This paves the way for even more sophisticated applications in precision farming, further transforming the agricultural landscape [10].

These ideas enable farmers to tailor their actions, encompassing irrigation, pest management, and fertilization to meet the requirements of their crops. This improvement results in increased productivity, reduced costs, and sustainability, giving farmers the ability to maximize productivity and utilize resources efficiently. Machine learning and data analytics are two main examples of AI technology successfully used in modern farming. Machine learning algorithms process data to find patterns and connections within vast amounts of crop data gathered from satellites and sensors. This data-driven approach equips farmers to take precise actions to understand the specific requirements of their farms. For instance, AI drones equipped with various types of sensors can capture comprehensive pictures of fields, which can then be analyzed to detect pest infestations, nutritional deficits, or disease outbreaks. This advantage allows farmers to apply targeted remedies to affected regions, eliminating the need for pesticides and fertilizers and minimizing damage to the environment. The power of AI also extends to yield estimation. AI algorithms precisely predict crop yield potential by analyzing data collected from various sources such as satellites, photography, and weather forecasts. By utilizing AI technologies, farmers can reduce their financial risks by making informed decisions about pricing, distribution, and storage. While AI in precision agriculture offers numerous advantages, challenges also arise. The initial risk lies in the high cost of AI technology, and issues of data security and connectivity in remote areas pose hurdles for farmers. In conclusion, precision agriculture is a technology that works in conjunction with agricultural practices to produce yields in a sustainable and productive manner for farmers. AI-powered solutions empower data-informed decisions, optimize resource management, boost yields, and diminish environmental impact. Precision agriculture has the potential to revolutionize crop cultivation methods, ensuring yield security for a growing global population.

Crop Monitoring and Management**AI methods in crop monitoring**

Artificial Intelligences mainly focused on pest control and crop protection, most importantly in weeds and disease management. It depends on the elements such as



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- Climate conduction
- Nutrition optimization
- Cultural activities and labour optimization
- Enhancing plant physiology and health

Climate conduction

Artificial Intelligences and robots plays a vital role, AI and robots collect advance information's like climate data, helps farmers to take important data about plantations, water usage amount and perfect crop selection. Robots monitor whether conduction, Soil moisture levels and pest outbreaks.

Nutrition optimization

For crops Nutrition is important for both yield, quality and quantity Artificial Intelligences in robotics helps in nutrient management by checking plant nutrient requirements, growth pattern, Soil composition. Artificial Intelligences in robotics helps for sustainable agriculture while decreasing environmental problems

Cultural activities and labour optimization

It is essential for successful crop production. Artificial Intelligences in robotics can reduce labor intensive efforts and maintains resources allocation. Time consuming activities like harvesting, purning and sorting can be easily done with great accuracy and efficiency.

Enhancing plant physiology and health

Artificial Intelligences can analyse large datasets like growth pattern, disease symptoms for early detection and intervention. Weeds can be identified and targeted using Artificial Intelligences sensors easily and then the appropriate herbicide can be applied in the areas. Artificial Intelligences in agriculture improves the quality of life for farmers and make agriculture more profitable profession [11].

Predictive Analytics**Understanding Yield Mapping in Precision Agriculture**

This document provides a comprehensive overview of yield mapping, a critical component of precision agriculture. It delves into the process of creating yield maps, the types of yield maps, the basic components of a yield mapping system, and the importance of these maps in modern farming practices. The insights presented are particularly relevant in the context of climate change and the need for sustainable agriculture [12].

Introduction to Yield Mapping

Yield mapping involves the collection of geo referenced or GPS data of crop yield and characteristics such as moisture content during harvest. This process utilizes a variety of sensors and has been a common practice in agriculture since the last decade of the 20th century. Yield mapping is essential for understanding spatial data in precision agriculture and making informed decisions regarding site-specific farming.

The Benefits of Variable Rate Application in Precision Agriculture

Variable rate application (VRA) is a key component of precision agriculture. By applying inputs such as fertilizer or pesticides at variable rates based on site-specific data, farmers can optimize resource allocation and minimize waste. This card explores the advantages of VRA, including improved crop yield, cost savings, and environmental sustainability.

Historical Background

The concept of yield mapping was first introduced in the research paper 'A yield map primer' by Blackmore in 1998. This paper provided practical guidelines for yield mapping and was presented in Japan. Subsequent research, such as 'Yield mapping; errors and algorithms' by Blackmore and Marshall in 1996, addressed early challenges by identifying six main errors in yield data collection



**Arun et al.,****Types of Yield Maps****Inference Maps**

- These maps combine yield estimates with existing map delineations without changing the base map, such as associating yield goals with a soil map

Prediction Maps

- Prediction maps use models to predict yield components based on spatial data like soil and weather properties

Interpolation Maps

- Interpolation techniques are applied to estimate yield values between measured data points at specific site locations [13]

Basic Components of Yield Mapping System**The Role of Drones in Precision Agriculture**

Unmanned aerial vehicles (UAVs), or drones, are becoming an increasingly popular tool in precision agriculture. By capturing high-resolution images and data, drones can provide farmers with valuable insights into crop health and growth patterns. This card explores the benefits and challenges of using drones in agriculture and highlights some of the latest research in the field. AI applications in irrigation and water management AI technologies optimize water usage by monitoring soil moisture levels, weather forecasts, and real-time crop water requirements. Moreover, AI facilitates the scheduling of irrigation activities to minimize water wastage and maintain optimal crop health. Smart Irrigation AI-driven irrigation systems ensure precise water delivery, avoiding over-watering and under watering. Weather Monitoring AI monitors weather changes to adjust irrigation schedules and mitigate potential risks to crop [14].

Agriculture Robotics

Farming is quickly becoming an appealing high tech sector that is attracting new professionals, companies and investors. The technology is developing, not simply enhancing manufacturing capability but likewise robotics and automation. At the core of this development lies the need for increasingly greater production yields. The UN anticipates the world population will grow from 7.3 billion today, to 9.7 billion in 2050. This population will require a lot more food, placing extreme stress on farmers to meet this demand. Agricultural robotics are raising production yields for farmers in a number of ways, with creative and innovative applications ranging from drones to autonomous tractors and robotic arms.

- Harvesting and picking
- Weed control
- Spraying
- packing

As artificial intelligence and robotics continue to advance, we can expect even more sophisticated applications to emerge. Imagine robots that can not only harvest crops but also adapt to changing weather conditions or identify and eliminate pests with pinpoint accuracy. The future of agriculture promises to be a fascinating blend of human expertise and technological innovation.

CONCLUSION

This review provides an overview of how AI technology's utilized in agriculture. While in some industries most of the work is carried out by intelligence thereby reducing the workload, for professionals and increasing productivity the scenario is quite different in agriculture. Here farmers are responsible for a majority of the work with AI playing a role. Tractors were first invented in 1892 representing cutting edge technology at that time. Initially many farmers couldn't afford tractors. Today they are commonly used. Unlike operating a tractor which requires driving skills utilizing AI integrated machinery demands education. In India, where the literacy rate among farmers stands at 59.56% educating farmers on using AI technology is crucial, for streamlining their work processes and making them more profitable.





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Table 1: Basic Components of Yield Mapping System

Grain flow sensor	Determines the volume of harvested grain
Grain moisture sensor	Compensates of variability in grain moisture
Clean grain elevator speed sensor	Improves accuracy of grain flow measurement
GPS antenna	Receives satellite signals
Yield monitor display with GPS receiver	Geo- References and Records data
Header position sensor	Distinguishes measurements logged during turns





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Travelling speed sensor	Measures combine travel during logging intervals
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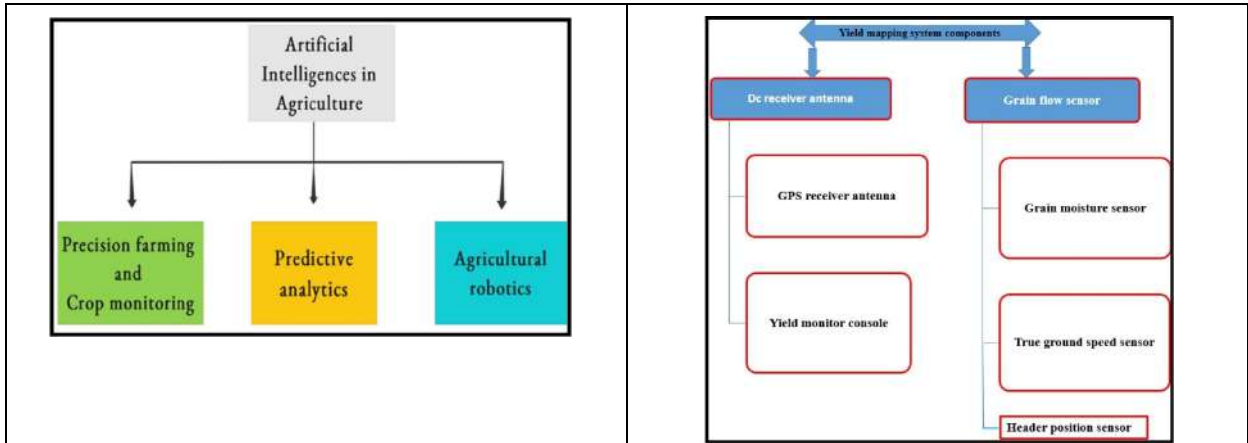


Fig 1: AI in agriculture

Fig 2: Yield mapping system components

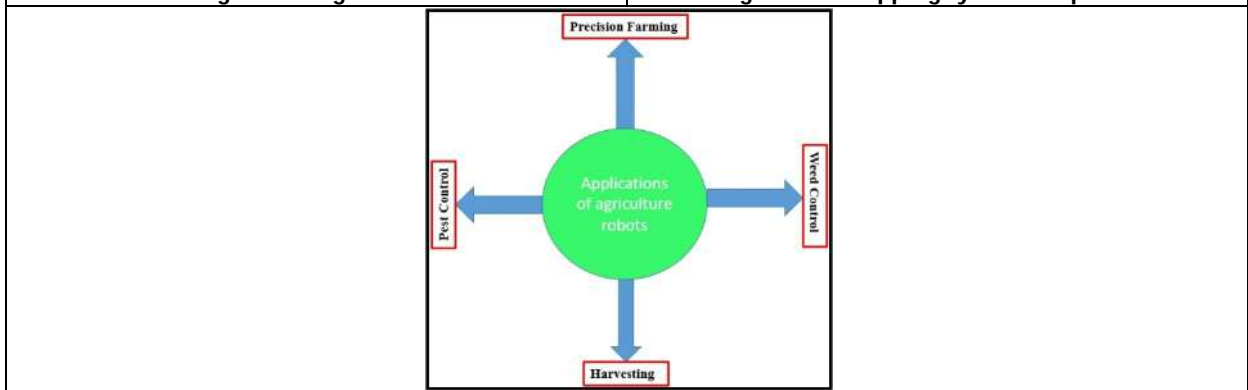


Fig 3: Applications of agriculture robots





Formulation and Development of Dual Purpose Bioadhesive Effervescent Tablet Dosage form for Vulvovaginal Candidiasis and Intestinal Helminth Infections using Garlic as an Active Moiety

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ABSTRACT

About 30 to 50 percent of women will at some point in their lives experience vulvovaginal candidiasis, or VVC. Moreover, on the other side, STH (Soil-transmitted helminths) infections pose a serious hazard to public health and are among the most prevalent infections in the globe. According to estimates from the World Health Organization (WHO), there were 1.5 billion STH infections worldwide in 2020, with over 267 million pre-schoolers and over 568 million school-age children residing in regions where these parasites are spread. Soil-transmitted helminths are transmitted to humans by contaminated soil. An effervescent bio-adhesive tablet dosage form was developed with an objective that vaginal discharge should not drain the dosage form out. Dosage form should remain adhered to mucosal linings after both vaginal application and oral consumption for helminth infections. Antifungal Susceptibility testing was performed using prepared tablet dosage form against *Candida albicans* (MTCC 277) as prominent species involved in fungal infections of vagina. Whereas anthelmintic activity was performed using *Pherentima posthuma* (Indian Earthworms) due to their anatomical and physiological resemblances with intestinal roundworm parasite of human beings. Tablet dosage form designed passed post compression parameters. The same tablet dosage form tested against *Candida albicans* and *Pherentima posthuma* (Indian Earthworms) was found to be effective and equivalent to marketed standard dosage forms for vaginal fungal infections and Intestinal helminth infections. Dual purpose applicability of dosage form could be cost-effective approach and could be the reasonable approach to proceed for product scale-up for multiple ailments.

Keywords: Garlic, Bio-Adhesive, *Candida albicans*, *Pherentima posthuma*, vaginal fungal infections, Intestinal helminth infections.





INTRODUCTION

Garlic has a substantial nutritional value and remarkable medicinal potential. It is discovered that garlic, which is used as a flavoring and spice, has basic essential elements. There are plenty of minerals, water, vitamins, protein, fat, and carbohydrates. Due to its strong therapeutic potential, garlic is used to treat a wide range of human ailments. Anti-inflammatory, rheumatological, ulcer-inhibiting, anticholinergic, analgesic, antimicrobial, antistress, antidiabetes, anticancer, liver protection, anthelmintics, antioxidants, antifungal, and wound-healing properties are just a few of the effects that have been reported. It also helps with asthma, arthritis, chronic fever, tuberculosis, runny nose, malaria, leprosy, skin discoloration, and itching, indigestion, colic, enlarged spleen, haemorrhoids, fistula, urinary tract disease, diabetes, kidney stones, anaemia, jaundice, epilepsy, cataract, and night blindness, among other conditions [1]. The Sanskrit language ancient texts on Ayurveda indicate that garlic has been used in India for over three millennia. "Garlic" is referred to in both manuscripts as Lasuna and by its synonym, Rasona. Similar applications have been observed not only in India as a whole but also in adjacent countries such as Nepal, Myanmar, Lao, Pakistan, Bangladesh, Bhutan, and Sri Lanka (South-East Asian region). Consequently, garlic has been used throughout India since ancient times [2].

Vulvovaginal candidiasis (VVC) affects between 30 and 50 percent of women at some point in their lives. A burning or itchy feeling (27%) and dysuria (33%) are common symptoms. *Candidates albicans*, *glabrata*, or *krusei* are the most common causes of VVC. [3]. Due to limited penetration into the biofilm matrix, resistance development, and the ineffectiveness of current antifungals in modifying virulence, *Candida albicans* mediated vulvovaginal candidiasis (VVC) poses a substantial problem in clinical settings. The dysbiosis of the normal vaginal microflora, the activation of central metabolic pathways, morphogenesis, hyphal extension, adhesion, invasion, and biofilm formation, which result in chronic infection and recurrence, are all caused by a variety of predisposition factors, which are molecular drivers [4].

In endemic places, infections with soil-transmitted helminths (STHs) pose a significant public health risk. Monitoring the disease's epidemiology is necessary for effective control. [5]. Due to the lack of clarity surrounding host-parasite interactions, helminthic diseases represent the main issue. The gastro-intestinal tract (GIT) helminth infection grows noticeably more resistant to the anthelmintic medications now on the market. A fresh interest in the natural therapy of common plant therapies and the significance of innate products in drug creation has emerged in the last few decades. This can be explained by the enormous need for new molecular models, which could result in the development of innovative medications that could validate routine therapeutic uses [6]. The World Health Organization reports that 35% diseases are because of roundworm, which is a typical parasitic worm. More than 1.5 billion individuals or 24% of the total population are tainted with soil-transmitted helminth contaminations around the world. [7]. The three primary species that infect humans are the whipworm (*Trichuris trichiura*), the roundworm (*Ascaris lumbricoides*), and the hookworms (*Necator americanus* and *Ancylostoma duodenale*). Due of their similar medical needs and responses to medications, these STH species are typically treated as a group.[8]The adult Indian earthworm *Pheretimaposthuma* was used for the testing because of its physiological and anatomical similarities to human intestinal roundworm parasites. A good model for anthelmintic medication screening is the *PheretimaPosthuma* worm, which is widely available [9].

In response to contemporary research demands, a project was conceived to develop a tablet dosage form tailored for women suffering from vulvovaginal candidiasis and patients afflicted with helminth infections. This initiative stems from the pressing need for effective and accessible treatment options for these prevalent conditions. Vulvovaginal candidiasis, caused by *Candida* species, presents a significant health burden among women worldwide, necessitating reliable therapeutic interventions to alleviate symptoms and prevent recurrence. Similarly, helminth infections, encompassing a range of parasitic worms, pose substantial health risks, particularly in regions with inadequate sanitation and hygiene practices. By targeting these two distinct yet clinically significant conditions, the project aims to address unmet medical needs and improve healthcare outcomes for affected populations. The development of a



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tablet dosage form offers several advantages, including convenience, ease of administration, and potentially enhanced patient compliance. Moreover, the formulation can be optimized to ensure stability, efficacy, and safety, meeting stringent regulatory standards for pharmaceutical products. Through interdisciplinary collaboration and rigorous scientific investigation, this project endeavors to advance the field of therapeutics, ultimately benefiting individuals grappling with vulvovaginal candidiasis and helminth infections.

MATERIALS AND METHODS**Preparation of garlic powder sample**

Garlic powder was prepared in-house by microwave drying process as per reported literature. [10]. All the reagents and chemicals used were of analytical grade and were procured from S.D. Fine-Chem. Ltd., Mumbai, India. All other chemicals, and excipients used in the study were of standard grade.

Procurement of species for antifungal and anthelmintic study

Candida albicans (MTCC 277) was sourced from the Microbial Type Culture Collection in Chandigarh, ensuring the authenticity and standardized quality of the strain. Concurrently, *Pheretima Posthuma* Earthworms were obtained from the local compost-making center in Nashik, selected for their relevance in helminth infection studies. To preserve the viability and integrity of these organisms, they were carefully maintained under optimal temperature conditions conducive to their growth and survival. This meticulous approach to procurement and maintenance ensures the reliability and consistency of the experimental materials, laying a robust foundation for subsequent research endeavors.

Development of Tablet Dosage form**Formulation of Vaginal Mucoadhesive Effervescent Tablet**

As the drug was proved to be effective against *Candida albicans*. The formulation was designed for the candidal vulvovaginitis. Hence by considering the site of application that is vagina the tablet must reside on vaginal mucosa and hence the same formula was continued by addition of Hydroxy propyl methy cellulose (HPMC K4M) in 3 different concentrations that is 5%, 10%, 15%. These 3 batches were evaluated and suitable batch was selected. Composition mentioned in Table-1. Method adopted for Tablet preparation was Direct Compression method. All ingredients including drug were weighed and passed through sieve no. 80 individually and then mixed. This powder mixture was compressed directly using Rimekmini press, model RSB-4,m/s (Karnavathi Engineering, Ahmadabad). [11]. Mucoadhesive effervescent tablet was evaluated for Hardness(gm/cm²), Effervescent time(min.), Disintegration time,(min.) Friability%, Mucoadhesion Strength Gm force (Table-4)

Mucoadhesion Test

Egg membrane was soaked in a SVF (Simulated Vaginal Fluid) over night. Mucoadhesion Test Apparatus was developed in lab using two pan analytical balance with slight modification. Two vials were used in which SVF was placed and covered with egg membrane soaked in SVF. one vial was fixed at bottom and another was tied in a vertical position in downward direction towards fixed vial and the apparatus was calibrated by keeping equivalent amount (32 gram) on opposite side of the balance. After calibrating, tablet was placed in between 2 vials and pressed by applying little force on it and then time required for Detachment of upper vial from Tablet was recorded. Same procedure was repeated for 3 tablets.[11,12]. Composition of simulated vaginal fluid used for mucoadhesion study is given in Table.2. Results are shown in Table 4

Antifungal Susceptibility testing of Mucoadhesive Effervescent Tablet [14].**Preparation of Sample for antifungal study**

A stock solution of 30 mg/ml was prepared.
Each tablet contains 400 mg of the drug





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That is 822.4 mg Tablet $\xrightarrow{\text{contains}}$ 400 mg of the drug

Hence x mg $\xrightarrow{\text{contains}}$ 300mg of the drug

$$x = \frac{300 * 822.4}{400}$$

$$=616.8 \text{ mg}$$

Tablet was crushed and the quantity of 616.8 mg was taken and dissolved in 5ml of DMF. To this test tube 5ml of SabourD Dextrose Broth was added. The study was performed in triplicate determination was performed after 72 hours

Fungal culture and Preparation of Inoculum

Fungal culture used was *candida albicans* (MTCC 227)

Inoculum 1×10^5 CFU/ml was standardized for the study.

0.9 ml of Inoculum was added to each test tube of the above set.

Growth Control

1) For positive growth control, 0.9 ml of final inoculums was added to 0.1 ml of broth.

2) For negative growth control, 1 ml of broth was taken in a tube.

Test tubes were incubated at 35 ± 0.5 °C. and observed at 72 h. The results are given in figure-1

In vitro Anthelmintic activity of Mucoadhesive Effervescent Tablet by Dissolution Methodology

Mucoadhesive effervescent tablet was evaluated for *in-vitro* anthelmintic activity by using petri plate assay method as well as the assay method using dissolution Apparatus. Considering our previous research work context where the methodology was screened and validated for the selection of bio-relevant media simulating *in-vivo* human gastrointestinal tract conditions. From the tested medias Saline solution (conventional method), Fed-State Simulated Gastric Fluid (Fe-SSGF) Early, Fasted-State Simulated Intestinal Fluid Updated version (FaSSIF-V2) were selected as an appropriate media for maintenance of worms. So in the present study Fa-SSIF-V2 was selected as media for Anthelmintic study (Table-3)[15]. Pheretimaposthumaworms (Adult Indian Earthworms) being easily available and due to their anatomical and physiological resemblance with the intestinal round worm parasites of human beings are used as a suitable model for anthelmintic screening of garlic powder and garlic formulations[16]. Dosage forms prepared were found to be equally effective at garlic concentration of 80 mg/ml compared to albendazole anthelmintic standard used. Results given in (Table-5, Table-6 and Figure-3).

Stability study

The one-month stability protocol, outlined in reference [17], was meticulously devised to evaluate the tablets' stability over time. Stored under ambient conditions with temperatures hovering around 30°C and relative humidity levels fluctuating between 30% and 55%, the tablets underwent rigorous scrutiny. Sampling intervals were strategically set at days 7, 14, 21, and 28 to capture potential changes in the tablets' properties. Beyond the anthelmintic assay conducted using a dissolution apparatus, a multifaceted approach was adopted. This encompassed assessments of physical attributes, weight variation, and chemical stability. By integrating diverse analyses, including dissolution behavior and overall physical integrity, the protocol endeavors to provide a comprehensive evaluation of the tablets' performance and quality throughout the stipulated one-month duration. The results are given in figure 4



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RESULT AND DISCUSSION

Formulation of Vaginal Mucoadhesive Effervescent Tablet

The evaluation of a mucoadhesive effervescent tablet revealed an outstanding mucoadhesion strength of 155 grams. This robust adhesion capability positions the developed dosage form as highly promising for applications in vaginal bioadhesive drug delivery systems. Such strong mucoadhesion is pivotal for ensuring sustained and localized drug delivery to the vaginal mucosa, which can significantly enhance therapeutic efficacy while minimizing systemic side effects. This characteristic makes the tablet particularly well-suited for delivering drugs intended for vaginal administration, such as antimicrobial agents, hormones, or contraceptives. The remarkable mucoadhesion strength of 155 grams underscores the potential of this dosage form to adhere firmly to the vaginal mucosa, allowing for prolonged contact and controlled release of the active pharmaceutical ingredient. This, in turn, could improve patient compliance and therapeutic outcomes, offering a more effective and convenient alternative to conventional dosage forms. Results given in table-4 [18].

Antifungal Susceptibility testing of Bioadhesive Effervescent Tablet

In a rigorous antifungal susceptibility test targeting *Candida albicans* species, we undertook a triplicate determination of the antifungal study using tablets. Throughout the experiment, meticulous control measures were maintained, including positive and negative controls, to ensure the reliability and accuracy of the results. Excitingly, the outcome of the study revealed a compelling finding: all three tubes containing the sample solution exhibited no growth even after continuous observation for up to 72 hours. This remarkable result suggests a potent antifungal activity associated with the tablets under investigation. The absence of fungal growth in the presence of the sample solution underscores the effectiveness of the tablets in inhibiting the growth and proliferation of *Candida albicans*. Such robust antifungal properties hold significant promise for combating fungal infections, particularly those caused by *Candida species*, which can be challenging to treat due to emerging resistance to conventional antifungal agents as shown in Figure-1.

In vitro Anthelmintic activity of Mucoadhesive Effervescent Tablet by Dissolution Methodology

In the Petri plate method, the average death time reported for 800 mg Garlic tablets was 110 minutes on average in comparison to the average death time of 96 minutes for Albendazole standard tablets 400 mg dose. It was found that the garlic tablet designed had significant comparable results as compared to the albendazole standard tablet dosage form. (Table-5, Table-6 and Figure-3) Interestingly, despite the discrepancy in dosage amounts, the Garlic tablets showcased a significant and comparable efficacy to the Albendazole standard tablets. This finding not only underscores the potential of Garlic as a viable alternative in combating certain microbial threats but also highlights the importance of exploring natural remedies in pharmaceutical research.

Stability Study Evaluation of Garlic Effervescent tablet in terms of Anthelmintic assay.

The stability studies conducted at ambient conditions, maintaining a temperature of around 30°C and relative humidity between 30-50%, yielded promising results over the one-month duration. The tablets were evaluated at intervals of 7, 14, 21 and 28 days. Death times ranging from 100 to 103 minutes indicated the tablets' stability, suggesting consistent therapeutic efficacy against worms. Comparative analysis with established anthelmintic medications like albendazole underscored the effectiveness of the developed tablets. Additionally, the significant performance of garlic tablets in the comparison highlights the potential of herbal remedies as valuable adjunct therapies in anthelmintic treatments. These findings collectively emphasize the durability, efficacy, and potential versatility of the developed formulation for combating parasitic infections. Results are depicted in figure 4.

CONCLUSION

The development of an effervescent bio-adhesive tablet dosage form marks a significant advancement in the treatment of vulvovaginal candidiasis (VVC) and soil-transmitted helminth (STH) infections. With the aim of



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ensuring effective treatment while overcoming challenges associated with conventional formulations, this innovative dosage form was meticulously designed and rigorously tested. Antifungal susceptibility testing against *Candida albicans*, the predominant species responsible for vaginal fungal infections, demonstrated the efficacy of the tablet dosage form. Through thorough evaluation, it was established that the tablet remained adhered to mucosal linings even after vaginal application, ensuring sustained delivery of antifungal agents to the site of infection. This not only enhances treatment efficacy but also reduces the likelihood of dosage form drainage, thus optimizing therapeutic outcomes. Moreover, the tablet dosage form exhibited remarkable anthelmintic activity against *Pheretimaphostuma*, an earthworm species commonly employed in research due to its physiological resemblance to intestinal roundworm parasites in humans. This dual-purpose functionality of the dosage form presents a novel approach to addressing multiple ailments, offering a cost-effective solution that streamlines treatment regimens and enhances patient compliance.

The successful completion of post-compression parameter testing further validates the quality and consistency of the tablet formulation. Importantly, comparative analysis against standard marketed dosage forms for both vaginal fungal infections and intestinal helminth infections reaffirms the equivalency and efficacy of the developed formulation. In conclusion, the dual-purpose applicability of the effervescent bio-adhesive tablet dosage form represents a promising advancement in pharmaceutical innovation. Not only does it offer a comprehensive solution for the management of VVC and STH infections, but it also presents a viable pathway for product scale-up and commercialization. By addressing the unmet needs of diverse patient populations, this innovative formulation has the potential to significantly impact public health on a global scale. Further research and development efforts are warranted to explore additional applications and optimize the clinical utility of this versatile dosage form.

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ETHICAL APPROVAL

Not applicable

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest

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Table 1. Composition of Trial batches for Mucoadhesive Effervescent tablet

Components	F1	F2	F3 (mg)
Drug (Garlic Powder)	400	400	400
Talc	10	10	10
Magnesium Stearate	10	10	10
Cross povidone	35	35	35
Citric Acid	120	120	120
Sodium Bicarbonate	131	131	131
HPMC K4 M	35	70	116.4

Table 2 Composition of Simulated Vaginal Fluid [13].

Composition	Quantity Gram/lit
NaCl	3.51
KOH	1.40
Calcium hydroxide	0.222
Bovine Serum Albumin	0.018





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Lactic Acid	2ml
Acetic Acid	1ml
Glycerol	0.16
Urea	0.40
Glucose	5.00
Distilled Water	q.s

Table-3 Composition of the medium to simulate the Fasted- State Upper Small Intestine: Fasted-State Simulated Intestinal Fluid, Updated Version (FaSSIF-V2)

Composition	mM
Sodium taurocholate	3
Lecithin	0.2
Maleic acid	19.12
Sodium hydroxide	34.8
Sodium chloride	68.62
Properties	
pH	6.5
Osmolality (mOsm/kg)	180 ± 10
Buffer Capacity (mmol/L/pH)	10

Table- 4 Evaluation of Mucoadhesive Effervescent tablet

Evaluation Parameters				
Hardness (gm/cm ²)	Effervescent time (min.)	Disintegration time (min.)	Friability %	Mucoadhesion Strength Gm force
4.5±0.058	21.47±0.4	22± 1.52	0.91±0.0057	155±1.73

Table.5 In vitro anthelmintic assay of Garlic Effervescent tablet

	Time (min.)						Average death Time(min)
	For Set I		For Set II		For Set III		
I.T	0	Mean	0	Mean	0	Mean	100.33±1.52
D.T	104	102	100	100	98	99	
D.T	100		100		100		

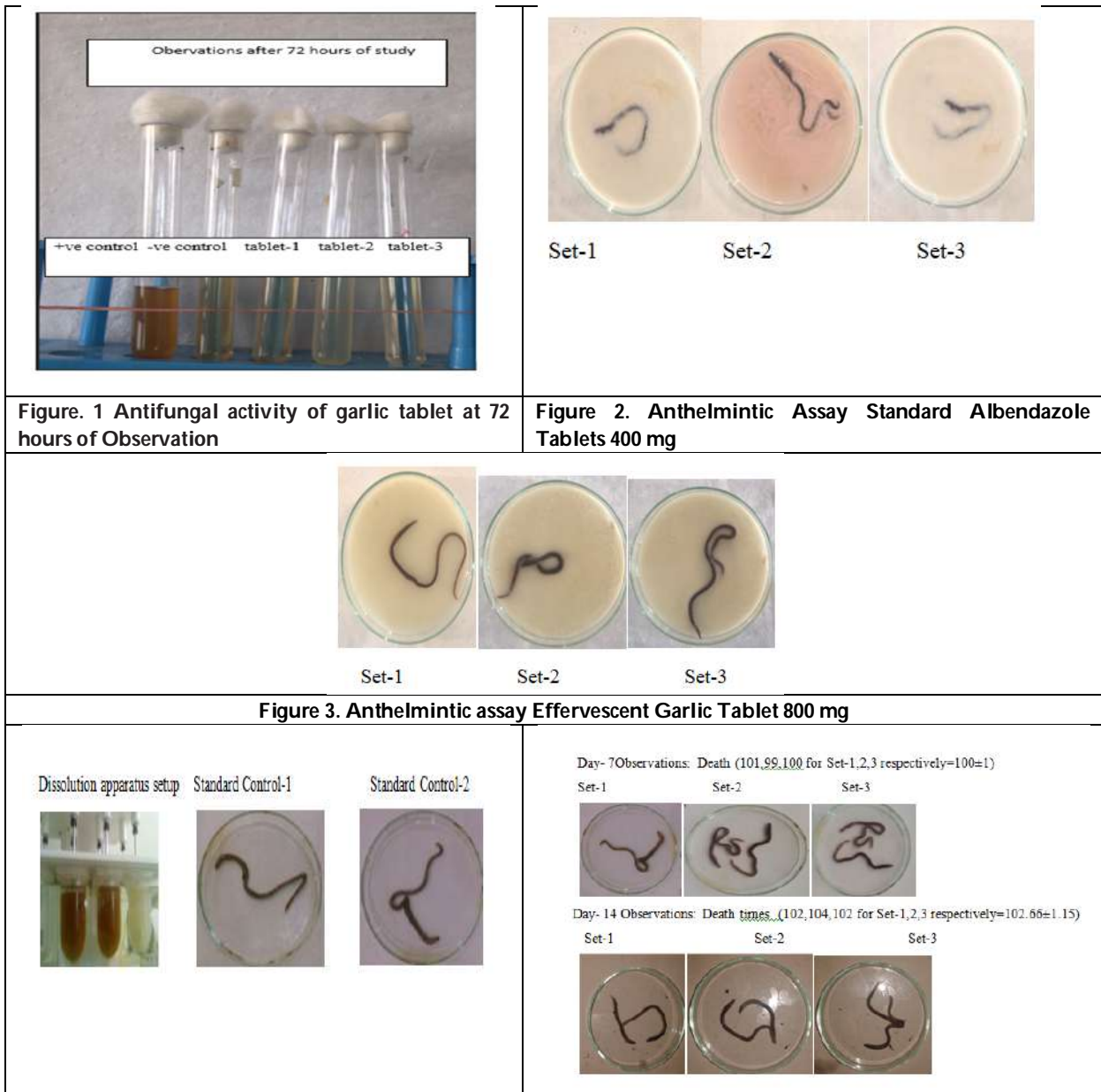
Table-6 Results of Anthelmintic Assay of Albendazole tablet

	Time (min.)						Average death Time(Min)
	For Set I		For Set II		For Set III		
I.T	0	Mean	0	Mean	0	Mean	96±3.32
D.T	90	92.5	98	97	100	99	
D.T-	95		96		98		



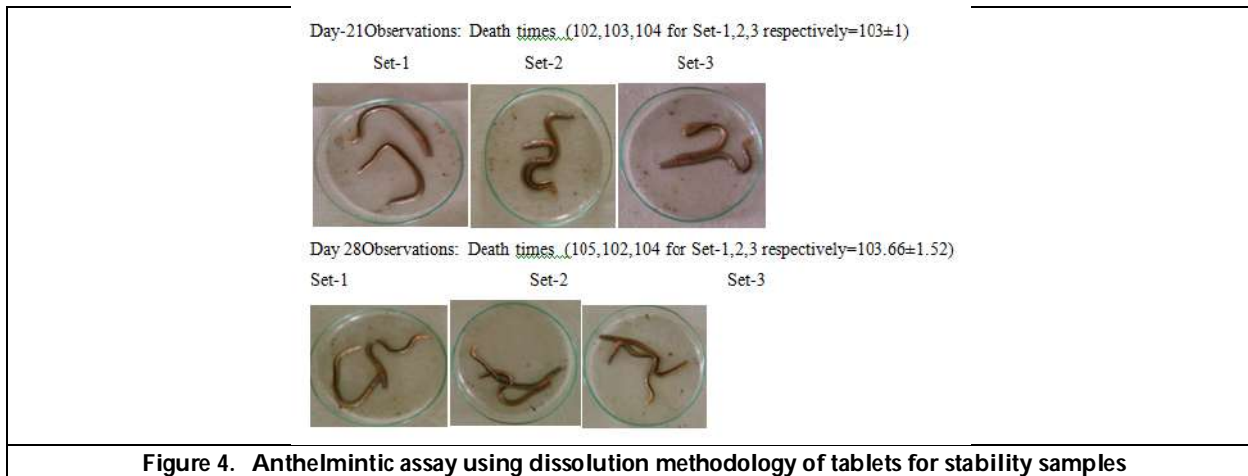


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Characterization of Q-Pythagorean Fuzzy Ideals in Γ -Semirings

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ABSTRACT

This paper deals with the Q-Pythagorean fuzzy sub semiring, ideals and bi-ideals in Γ -semirings. Moreover we study the properties of Q-Pythagorean fuzzy ideals in Γ -semiring.

Keywords: Γ -semiring, Q-Pythagorean fuzzy set, Q-Pythagorean fuzzy ideal, Q-Pythagorean fuzzy bi-ideal.

INTRODUCTION

Zadeh's[15] seminal paper introduced the concept of fuzzy sets and their operations, sparking significant interest among mathematicians across various fields. Since then, Zadeh and other scholars have further developed fuzzy set theory, garnering considerable attention from researchers. Pythagorean fuzzy sets[13][14] characterized by the condition that the sum of the squares of membership and non-membership degrees is less than or equal to one, have been extensively investigated. Numerous authors have explored the algebraic properties of Pythagorean fuzzy ideals. This paper is structured into five sections. The initial two sections provide an introduction and lay down the preliminary concepts. The third section delves into the exploration of Q-Pythagorean fuzzy ideals within Γ -semirings. Following that, the fourth section examines the properties associated with Q-pythagorean fuzzy ideals. Lastly, the paper concludes by investigating Q-Pythagorean fuzzy bi-ideals in Γ -semirings.

PRELIMINARIES

In this section we present the basic concepts related to this paper.





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Definition 2.1 [3] If $(S, +)$ and $(\Gamma, +)$ be two commutative semigroups then S is called a Γ -semiring if there exists a mapping $S \times \Gamma \times S$ denoted by $\alpha\gamma\beta$ for all $\alpha, \beta \in S$ and $\gamma \in \Gamma$ satisfying the following properties,

$$\begin{aligned} \alpha\gamma(\beta + \nu) &= \alpha\gamma\beta + \alpha\gamma\nu, \\ (\beta + \nu)\gamma\alpha &= \beta\gamma\alpha + \nu\gamma\alpha, \\ \alpha(\gamma + \gamma_1)\nu &= \alpha\gamma\nu + \alpha\gamma_1\nu, \\ \alpha\gamma(\beta\gamma_1\nu) &= (\alpha\gamma\beta)\gamma_1\nu \\ \text{for all } \alpha, \beta, \nu \in S \text{ and } \gamma, \gamma_1 \in \Gamma. \end{aligned}$$

Definition 2.2 [3] Define addition in the following way $A, B \in S, \gamma \in \Gamma$, let $A\gamma B$ denote the ideal generated by $\{\alpha\gamma\beta/\alpha, \beta \in S\}$. Then S is a Γ -semiring.

Definition 2.3 [3] A Γ -semiring S is said to be commutative if $\alpha\gamma\beta = \beta\gamma\alpha$, for all $\alpha, \beta \in S$ and $\gamma \in \Gamma$.

Definition 2.4 [3] A Γ -semiring S is said to have a zero element if $0\beta\alpha = 0 = \alpha\beta 0$ and $\alpha + 0 = \alpha = 0 + \alpha$, for all $\alpha \in S$ and $\gamma \in \Gamma$.

Definition 2.5 [3] S is said to have a identity element if there exists $\gamma \in \Gamma$ such that $1\gamma\alpha = \alpha = \alpha\gamma 1$ for all $\alpha \in S$.

Definition 2.6 [3] S is said to have a strong identity element if for all $\alpha \in S$, $1\gamma\alpha = \alpha = \alpha\gamma 1$ for all $\gamma \in \Gamma$.

Definition 2.7 [3] A non empty subset R of a Γ -semiring S is said to be a sub Γ -semiring of S if $(R, +)$ is a sub semigroup of $(S, +)$ and $\alpha\gamma\beta \in R$ for all $\alpha, \beta \in R$ and $\gamma \in \Gamma$.

Definition 2.8 [3] A non empty subset R of a Γ -semiring S is called an ideal if $\alpha, \beta \in R$ implies $\alpha + \beta \in R$ and $a \in R, \alpha \in S$ and $\gamma \in \Gamma$ implies $\alpha\gamma a \in R$ and $a\alpha\gamma \in R$.

Definition 2.9 [13] Let X be a non empty set. A Pythagorean Fuzzy Set \mathfrak{A} in X is given by $\mathfrak{A} = \{\alpha, \mathfrak{A}_x(\alpha), \mathfrak{A}_y(\alpha)/\alpha \in X\}$ where $\mathfrak{A}_x: X \rightarrow [0,1]$ and $\mathfrak{A}_y: X \rightarrow [0,1]$ represent the degree of membership and degree of non membership of \mathfrak{A} respectively. Also, \mathfrak{A}_x and \mathfrak{A}_y satisfies the condition $(\mathfrak{A}_x)^2 + (\mathfrak{A}_y)^2 \leq 1$ for all $\alpha \in X$.

Definition 2.10 [5] Let U be an universal set and Q be a nonempty set. A Q -Pythagorean fuzzy set is an object having the following form, $A: U \times Q \rightarrow [0,1]$

$A = \{(\alpha, q), (A_x(\alpha, q), A_y(\alpha, q))/\alpha \in U, q \in Q\}$ where $A_x(\alpha, q)$ and $A_y(\alpha, q)$ degree of membership and degree of non membership. Also A_x and A_y satisfies the condition $0 \leq (A_x)^2 + (A_y)^2 \leq 1$ for all $\alpha \in X$

Definition 2.11 [5] Let A and B be two Q -Pythagorean fuzzy set of S . Then the union of A and B is a Q -Pythagorean fuzzy set defined by

$$\begin{aligned} (A_x \cup B_x)(u, q) &= \max\{A_x(u, q), B_x(u, q)\} \\ (A_y \cup B_y)(u, q) &= \min\{A_y(u, q), B_y(u, q)\} \\ \text{for all } u \in S \text{ and } q \in Q. \end{aligned}$$

Definition 2.12 [5] Let A and B be two Q -Pythagorean fuzzy set of S . Then the intersection of A and B is a Q -Pythagorean fuzzy set defined by

$$\begin{aligned} (A_x \cap B_x)(u, q) &= \min\{A_x(u, q), B_x(u, q)\} \\ (A_y \cap B_y)(u, q) &= \max\{A_y(u, q), B_y(u, q)\} \\ \text{for all } u \in S \text{ and } q \in Q. \end{aligned}$$





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Q-Pythagorean fuzzy ideal in Γ -semirings

In this section, we present the notion of Q -Pythagorean fuzzy ideals within γ -semirings, along with exploring some intriguing properties associated with them.

Definition 3.1 A Q -Pythagorean fuzzy set A in S is called a Q -Pythagorean fuzzy subsemiring in S if the following conditions are hold for all $\alpha, \beta \in S, \gamma \in \Gamma$

1. $A_x(\alpha + \beta, q) \geq A_x(\alpha, q) \wedge A_x(\beta, q)$
 $A_y(\alpha + \beta, q) \leq A_y(\alpha, q) \vee A_y(\beta, q)$
2. $A_x(\alpha\gamma\beta, q) \geq A_x(\alpha, q) \wedge A_x(\beta, q)$
 $A_y(\alpha\gamma\beta, q) \leq A_y(\alpha, q) \vee A_y(\beta, q)$

Definition 3.2 A Q -Pythagorean fuzzy set A in S is called a Q -Pythagorean fuzzy left ideal in S if the following conditions are hold for all $\alpha, \beta \in S, \gamma \in \Gamma$.

1. $A_x(\alpha + \beta, q) \geq A_x(\alpha, q) \wedge A_x(\beta, q)$
 $A_y(\alpha + \beta, q) \leq A_y(\alpha, q) \vee A_y(\beta, q)$
2. $A_x(r\gamma\alpha, q) \geq A_x(\alpha, q)$
 $A_y(r\gamma\alpha, q) \leq A_y(\alpha, q)$

Definition 3.3 A Q -Pythagorean fuzzy set A in S is called a Q -Pythagorean fuzzy right ideal in S if the following conditions are hold for all $\alpha, \beta \in S, \gamma \in \Gamma$.

1. $A_x(\alpha + \beta, q) \geq A_x(\alpha, q) \wedge A_x(\beta, q)$
 $A_y(\alpha + \beta, q) \leq A_y(\alpha, q) \vee A_y(\beta, q)$
2. $A_x(\alpha\gamma r, q) \geq A_x(\alpha, q)$
 $A_y(\alpha\gamma r, q) \leq A_y(\alpha, q)$

Definition 3.4 A Q -Pythagorean fuzzy set A in S is called a Pythagorean anti fuzzy ideal in S if it is both Q -pythagorean fuzzy left ideal and pythagorean anti fuzzy right ideal of S .

Example 3.5 Let $S = \{0,1,2,3\}$ be a Γ -semiring with the following multiplication table.

+	0	1	2	3
	0	1	2	3
	1	1	2	3
	2	2	2	3
	3	3	3	2

•	0	1	2	3
	0	0	0	0
	0	1	1	1
	0	1	1	1
	0	1	1	1

Let A be a Q -Pythagorean fuzzy set of S defined by, $A_x(i, q) = \{0.5,0.5,0.3,0.2\}$, $A_y(i, q) = \{0.6,0.7,0.9,0.9\}$. Then A is a Q -Pythagorean fuzzy ideal of S .

Properties of Q -Pythagorean fuzzy ideals in Γ -semiring

In this section we characterize Q -Pythagorean fuzzy ideals in Γ -semiring

Lemma 4.1 If A is a Q -Pythagorean fuzzy set in S satisfies $A_x(0) \geq A_x(\alpha)$ and $A_y(0) \leq A_y(\alpha)$.





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Lemma 4.2 Every Q -Pythagorean fuzzy ideal in S is an Q -Pythagorean fuzzy subsemiring of S .

Theorem 4.3 Let A and B are Q -Pythagorean fuzzy subsemiring of S then $A \cap B$ is also Q -Pythagorean fuzzy subsemiring of S .

Proof. Since A and B are Q -Pythagorean fuzzy subsemiring of S .

Then for all $\alpha, \beta \in S, \gamma \in \Gamma$.

$$\begin{aligned} (A_x \cap B_x)(\alpha + \beta, q) &= (A_x \wedge B_x)(\alpha + \beta, q) \\ &= A_x(\alpha + \beta, q) \wedge B_x(\alpha + \beta, q) \\ &\geq (A_x(\alpha, q) \wedge A_x(\beta, q)) \wedge (B_x(\alpha, q) \wedge B_x(\beta, q)) \\ &\geq (A_x(\alpha, q) \wedge B_x(\alpha, q)) \wedge (A_x(\beta, q) \wedge B_x(\beta, q)) \\ &= (A_x \wedge B_x)(\alpha, q) \wedge (A_x \wedge B_x)(\beta, q) \\ &= (A_x \cap B_x)(\alpha, q) \wedge (A_x \cap B_x)(\beta, q) \end{aligned}$$

$$\begin{aligned} (A_y \cap B_y)(\alpha + \beta, q) &= (A_y \cap B_y)(\alpha + \beta, q) \\ &= A_y(\alpha + \beta, q) \wedge B_y(\alpha + \beta, q) \\ &\leq (A_y(\alpha, q) \vee A_y(\beta, q)) \wedge (B_y(\alpha, q) \vee B_y(\beta, q)) \\ &\leq (A_y(\alpha, q) \wedge B_y(\alpha, q)) \wedge (A_y(\beta, q) \wedge B_y(\beta, q)) \\ &= (A_y \wedge B_y)(\alpha, q) \vee (A_y \wedge B_y)(\beta, q) \end{aligned}$$

and

$$\begin{aligned} (A_x \cap B_x)(\alpha\gamma\beta, q) &= (A_x \wedge B_x)(\alpha\gamma\beta, q) \\ &= A_x(\alpha\gamma\beta, q) \wedge B_x(\alpha\gamma\beta, q) \\ &\geq A_x(\beta, q) \wedge B_x(\beta, q) \\ &= (A_x \wedge B_x)(\beta, q) \end{aligned}$$

Also $(A_x \cap B_x)(\alpha\gamma\beta, q) = (A_x \wedge B_x)(\alpha\gamma\beta, q)$

$$\begin{aligned} &= A_x(\alpha\gamma\beta, q) \wedge B_x(\alpha\gamma\beta, q) \\ &\geq A_x(\alpha, q) \wedge B_x(\alpha, q) \\ &= (A_x \wedge B_x)(\alpha, q) \end{aligned}$$

Moreover

$$\begin{aligned} (A_y \cap B_y)(\alpha\gamma\beta, q) &= (A_y \vee B_y)(\alpha\gamma\beta, q) \\ &= A_y(\alpha\gamma\beta, q) \vee B_y(\alpha\gamma\beta, q) \\ &\leq A_y(\beta, q) \vee B_y(\beta, q) \\ &= (A_y \vee B_y)(\beta, q) \end{aligned}$$

and

$$\begin{aligned} (A_y \cap B_y)(\alpha\gamma\beta, q) &= (A_y \vee B_y)(\alpha\gamma\beta, q) \\ &= A_y(\alpha\gamma\beta, q) \vee B_y(\alpha\gamma\beta, q) \\ &\leq A_y(\beta, q) \vee B_y(\alpha, q) \\ &= (A_y \vee B_y)(\alpha, q) \end{aligned}$$

Hence $A \cap B$ is a Q -Pythagorean fuzzy subsemiring of S .

Theorem 4.4 Let A and B are Q -Pythagorean fuzzy ideal of S then $A \cap B$ is also Q -Pythagorean fuzzy ideal of S .

Proof. Since A and B are Q -Pythagorean fuzzy ideal of S .

Then for all $\alpha, \beta \in S, \gamma \in \Gamma$.

$$\begin{aligned} (A_x \cap B_x)(\alpha + \beta, q) &= (A_x \wedge B_x)(\alpha + \beta, q) \\ &= A_x(\alpha + \beta, q) \wedge B_x(\alpha + \beta, q) \\ &\geq (A_x(\alpha, q) \wedge A_x(\beta, q)) \wedge (B_x(\alpha, q) \wedge B_x(\beta, q)) \end{aligned}$$





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$$\begin{aligned} &\geq (A_x(\alpha, q) \wedge B_x(\alpha, q)) \wedge (A_x(\beta, q) \wedge B_x(\beta, q)) \\ &= (A_x \wedge B_x)(\alpha, q) \wedge (A_x \wedge B_x)(\beta, q) \\ &= (A_x \cap B_x)(\alpha, q) \wedge (A_x \cap B_x)(\beta, q) \end{aligned}$$

$$\begin{aligned} (A_y \cap B_y)(\alpha + \beta, q) &= (A_y \cap B_y)(\alpha + \beta, q) \\ &= A_y(\alpha + \beta, q) \wedge B_y(\alpha + \beta, q) \\ &\leq (A_y(\alpha, q) \vee A_y(\beta, q)) \wedge (B_y(\alpha, q) \vee B_y(\beta, q)) \\ &\leq (A_y(\alpha, q) \vee B_y(\alpha, q)) \wedge (A_y(\beta, q) \vee B_y(\beta, q)) \\ &= (A_y \vee B_y)(\alpha, q) \wedge (A_y \vee B_y)(\beta, q) \\ &= (A_y \cap B_y)(\alpha, q) \wedge (A_y \cap B_y)(\beta, q) \end{aligned}$$

and

$$\begin{aligned} (A_x \cap B_x)(\alpha\gamma r, q) &= (A_x \wedge B_x)(\alpha\gamma r, q) \\ &= A_x(\alpha\gamma r, q) \wedge B_x(\alpha\gamma r, q) \\ &\geq A_x(\alpha, q) \wedge B_x(\alpha, q) \\ &= (A_x \cap B_x)(\alpha, q) \\ (A_y \cap B_y)(\alpha\gamma r, q) &= (A_y \cap B_y)(\alpha\gamma r, q) \\ &= A_y(\alpha\gamma r, q) \vee B_y(\alpha\gamma r, q) \\ &\leq A_y(\alpha, q) \vee B_y(\alpha, q) \\ &= (A_y \cap B_y)(\alpha, q) \end{aligned}$$

Finally

$$\begin{aligned} (A_x \cap B_x)(r\gamma\alpha, q) &= (A_x \wedge B_x)(r\gamma\alpha, q) \\ &= A_x(r\gamma\alpha, q) \wedge B_x(r\gamma\alpha, q) \\ &\geq A_x(\alpha, q) \wedge B_x(\alpha, q) \\ &= (A_x \cap B_x)(\alpha, q) \\ (A_y \cap B_y)(r\gamma\alpha, q) &= (A_y \cap B_y)(r\gamma\alpha, q) \\ &= A_y(r\gamma\alpha, q) \vee B_y(r\gamma\alpha, q) \\ &\leq A_y(\alpha, q) \vee B_y(\alpha, q) \\ &= (A_y \cap B_y)(\alpha, q) \end{aligned}$$

Hence $A \cap B$ is a Q -Pythagorean fuzzy ideal of S .

Theorem 4.5 Let G and H be two Γ -semirings and π be a homomorphism of G onto H . If A is a Q -Pythagorean fuzzy ideal of H , then $\pi^{-1}(A)$ is a Q -Pythagorean fuzzy ideal of G .

Proof. Since G and H be two Γ semirings and π be a homomorphism of G onto H . If A is a Q -Pythagorean fuzzy ideal of H .

Then $\pi^{-1}(A_x(\alpha, q)) = A_x(\pi(\alpha, q))$ and $\pi^{-1}(A_y(\alpha, q)) = A_y(\pi(\alpha, q))$ for all $\alpha \in G$. Let $\alpha, \beta \in G, \gamma \in \Gamma$.

Then

$$\begin{aligned} \pi^{-1}(A_x)(\alpha + \beta, q) &= A_x(\pi(\alpha + \beta, q)) \\ &= A_x(\pi(\alpha, q) + \pi(\beta, q)) \\ &\geq A_x(\pi(\alpha, q)) \wedge A_x(\pi(\beta, q)) \\ &= \pi^{-1}(A_x)(\alpha, q) \wedge \pi^{-1}(A_x)(\beta, q) \\ \pi^{-1}(A_y)(\alpha + \beta, q) &= A_y(\pi(\alpha + \beta, q)) \\ &= A_y(\pi(\alpha, q) + \pi(\beta, q)) \\ &\leq A_y(\pi(\alpha, q)) \vee A_y(\pi(\beta, q)) \\ &= \pi^{-1}(A_y)(\alpha, q) \vee \pi^{-1}(A_y)(\beta, q) \end{aligned}$$

Next we have to prove for Q -pythagorean fuzzy left ideal

$$\begin{aligned} \pi^{-1}(A_x)(r\gamma\alpha, q) &= A_x(\pi(r\gamma\alpha, q)) \\ &= A_x(\pi(r, q)\gamma\pi(\alpha, q)) \\ &\geq A_x(\pi(\alpha, q)) \\ &= \pi^{-1}(A_x)(\alpha, q) \\ \pi^{-1}(A_y)(r\gamma\alpha, q) &= A_y(\pi(r\gamma\alpha, q)) \\ &= A_y(\pi(r, q)\gamma\pi(\alpha, q)) \end{aligned}$$





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$$\begin{aligned} &\leq A_y(\pi(\alpha, q)) \\ &= \pi^{-1}(A_y)(\alpha, q) \end{aligned}$$

Finally we have to prove for Q -pythagorean fuzzy right ideal

$$\begin{aligned} \pi^{-1}(A_x)(\alpha\gamma r, q) &= A_x(\pi(\alpha\gamma r, q)) \\ &= A_x(\pi(\alpha, q)\gamma\pi(r, q)) \\ &\leq A_x(\pi(\alpha, q)) \\ &= \pi^{-1}(A_x)(\alpha, q) \\ \pi^{-1}(A_y)(\alpha\gamma r, q) &= A_y(\pi(\alpha\gamma r, q)) \\ &= A_y(\pi(\alpha, q)\gamma\pi(r, q)) \\ &\leq A_y(\pi(\alpha, q)) \\ &= \pi^{-1}(A_y)(\alpha, q) \end{aligned}$$

Hence Proved.

Theorem 4.6 If A and B are any two Q -Pythagorean fuzzy ideal of Γ -semirings S_1 and S_2 respectively then $A \times B$ is a Q -Pythagorean fuzzy ideal of $S_1 \times S_2$.

Proof. Since A and B be any two Q -Pythagorean fuzzy ideal of Γ -semirings S_1 and S_2 respectively.

Let $p_1, p_2 \in S_1$ and $k_1, k_2 \in S_2$.

Then consider $(p_1, k_1), (p_2, k_2) \in S_1 \times S_2, \gamma \in \Gamma$

$$\begin{aligned} (A_x \times B_x)((p_1, k_1) + (p_2, k_2), q) &= (A_x \times B_x)((p_1 + p_2, k_1 + k_2), q) \\ &\geq \min\{A_x(p_1 + p_2, q), B_x(k_1 + k_2, q)\} \\ &\geq \min\{A_x(p_1, q) \wedge A_x(p_2, q), B_x(k_1, q) \wedge B_x(k_2, q)\} \\ &\geq \min\{A_x(p_1, q) \wedge B_x(k_1, q), A_x(p_2, q) \wedge B_x(k_2, q)\} \\ &= \min\{(A_x \times B_x)((p_1, k_1), q), (A_x \times B_x)((p_2, k_2), q)\} \end{aligned}$$

And

$$\begin{aligned} (A_y \times B_y)((p_1, k_1) + (p_2, k_2), q) &= (A_y \times B_y)((p_1 + p_2, k_1 + k_2), q) \\ &\leq \max\{A_y(p_1 + p_2, q), B_y(k_1 + k_2, q)\} \\ &\leq \max\{A_y(p_1, q) \wedge A_y(p_2, q), B_y(k_1, q) \wedge B_y(k_2, q)\} \\ &\leq \max\{A_x(p_1, q) \wedge B_y(k_1, q), A_y(p_2, q) \wedge B_y(k_2, q)\} \\ &= \max\{(A_y \times B_y)((p_1, k_1), q), (A_y \times B_y)((p_2, k_2), q)\} \end{aligned}$$

Finally

$$\begin{aligned} (A_x \times B_x)((p_1, k_1)\gamma(p_2, k_2), q) &= (A_x \times B_x)(p_1\gamma p_2, k_1\gamma k_2, q) \\ &\geq \min\{A_x(p_1\gamma p_2, q), B_x(k_1\gamma k_2, q)\} \\ &\geq \min\{A_x(p_2, q), B_x(k_2, q)\} \\ &= (A_x \times B_x)((p_2, k_2), q) \end{aligned}$$

and

$$\begin{aligned} (A_y \times B_y)((p_1, k_1)\gamma(p_2, k_2), q) &= (A_y \times B_y)(p_1\gamma p_2, k_1\gamma k_2, q) \\ &\leq \max\{A_y(p_1\gamma p_2, q), B_y(k_1\gamma k_2, q)\} \\ &\leq \max\{A_y(p_1, q), B_y(k_1, q)\} \\ &= (A_y \times B_y)((p_1, k_1), q) \end{aligned}$$

Hence $A \times B$ is a Q -Pythagorean fuzzy ideal.

Q -Pythagorean fuzzy bi-ideals in Γ -semirings

In this section we discuss some interesting properties of Q -Pythagorean fuzzy bi-ideals in Γ -semirings.





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Definition 5.1 A Q-Pythagorean fuzzy ideal A in S is called a Q-Pythagorean fuzzy bi-ideal in S if the following conditions are hold for all $\alpha, \beta \in S, \gamma \in \Gamma$.

- (i) $A_x(\alpha\gamma_1\eta\gamma_2\beta, q) \geq A_x(\alpha, q) \wedge A_x(\beta, q)$
- (ii) $A_y(\alpha\gamma_1\eta\gamma_2\beta, q) \leq A_y(\alpha, q) \vee A_x(\beta, q)$

Theorem 5.2 Let A be a Q-Pythagorean fuzzy ideal in S. If S is an intra regular then $A(\alpha, q) = A(\alpha\gamma\alpha, q)$ for all $\alpha \in S, \gamma \in \Gamma$

Proof. Let α be any element of S. Then since S is a intra-regular, there exist $x, y \in S$ and $\gamma_1, \gamma_2, \gamma_3 \in \Gamma$ such that $\alpha = x\gamma_1\alpha\gamma_2\alpha\gamma_3y$. Hence A is a Q-Pythagorean fuzzy ideal.

$$\begin{aligned} A_x(\alpha, q) &= A_x(x\gamma_1\alpha\gamma_2\alpha\gamma_3y, q) \\ &\geq A_x(x\gamma_1\alpha\gamma_2\alpha, q) \\ &\geq A_x(\alpha\gamma_2\alpha, q) \\ &\geq A_x(\alpha, q) \end{aligned}$$

and

$$\begin{aligned} A_y(\alpha, q) &= A_y(x\gamma_1\alpha\gamma_2\alpha\gamma_3y, q) \\ &\leq A_y(x\gamma_1\alpha\gamma_2\alpha, q) \\ &\leq A_y(\alpha\gamma_2\alpha, q) \\ &\leq A_y(\alpha, q) \end{aligned}$$

Hence the theorem.

Theorem 5.3 Let A be a Q-Pythagorean fuzzy ideal in S. If S is an intra regular then $A(\alpha\gamma\beta, q) = A(\beta\gamma\alpha, q)$ for all $\alpha, \beta \in S, \gamma \in \Gamma$

Proof. Let α, β be any element of S. Then by theorem 5.2 we have,

$$\begin{aligned} A_x(\alpha\gamma\beta, q) &= A_x(\alpha\gamma\beta\gamma\alpha\gamma\beta, q) \\ &\geq A_x(\alpha\gamma(\beta\gamma\alpha)\gamma\beta, q) \\ &\geq A_x(\beta\gamma\alpha, q) \\ &\geq A_x(\beta\gamma\alpha\gamma\beta\gamma\alpha, q) \\ &\geq A_x(\beta\gamma(\alpha\gamma\beta)\gamma\alpha, q) \\ &\geq A_x(\alpha\gamma\beta, q) \end{aligned}$$

and

$$\begin{aligned} A_y(\alpha\gamma\beta, q) &= A_y(\alpha\gamma\beta\gamma\alpha\gamma\beta, q) \\ &\leq A_y(\alpha\gamma(\beta\gamma\alpha)\gamma\beta, q) \\ &\leq A_y(\beta\gamma\alpha, q) \\ &\leq A_y(\beta\gamma\alpha\gamma\beta\gamma\alpha, q) \\ &\leq A_y(\beta\gamma(\alpha\gamma\beta)\gamma\alpha, q) \\ &\leq A_y(\alpha\gamma\beta, q) \end{aligned}$$

Hence the theorem.

Theorem 5.4 Let A be a Q-Pythagorean fuzzy bi-ideal of S if and only if the fuzzy set A_x and \overline{A}_y are fuzzy bi-ideals of S

Proof. Let A be a Q-Pythagorean fuzzy bi-ideal in S. Then A_x is a Q-fuzzy bi-ideal of S. Let $\alpha, \beta \in S, \gamma_1, \gamma_2 \in \Gamma$. Then

$$\begin{aligned} \overline{A}_y(\alpha\gamma_1\beta, q) &= 1 - A_y(\alpha\gamma_1\beta, q) \\ &\geq 1 - \max\{A_y(\alpha, q), A_y(\beta, q)\} \\ &= \min\{1 - A_y(\alpha, q), 1 - A_y(\beta, q)\} \\ &= \min\{\overline{A}_y(\alpha, q), \overline{A}_y(\beta, q)\} \text{ and} \end{aligned}$$





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$$\begin{aligned} \overline{A}_y(\alpha\gamma_1r\gamma_2\beta, q) &= 1 - A_y(\alpha\gamma_1r\gamma_2\beta, q) \\ &\geq 1 - \max\{A_y(\alpha, q), A_y(\beta, q)\} \\ &= \min\{1 - A_y(\alpha, q), 1 - A_y(\beta, q)\} \\ &= \min\{\overline{A}_y(\alpha, q), \overline{A}_y(\beta, q)\} \end{aligned}$$

Hence \overline{A}_y is a Q -Pythagorean fuzzy bi-ideal of S . Conversely, suppose that A_x and \overline{A}_y are Q -Pythagorean fuzzy bi-ideal of S , Let $\alpha, r, \beta \in S, \gamma_1, \gamma_2 \in \Gamma$.

Then

$$\begin{aligned} 1 - A_x(\alpha\gamma_1\beta, q) &= \overline{A}_x(\alpha\gamma_1\beta, q) \\ &\geq \min\{\overline{A}_x(\alpha, q), \overline{A}_x(\beta, q)\} \\ &= \min\{1 - A_x(\alpha, q), 1 - A_x(\beta, q)\} \\ &= \max\{A_x(\alpha, q), A_x(\beta, q)\} \end{aligned}$$

and

$$\begin{aligned} 1 - A_x(\alpha\gamma_1r\gamma_2\beta, q) &= \overline{A}_x(\alpha\gamma_1r\gamma_2\beta, q) \\ &\geq \min\{\overline{A}_x(\alpha, q), \overline{A}_x(\beta, q)\} \\ &= 1 - \max\{A_x(\alpha, q), A_x(\beta, q)\} \\ &= \max\{A_x(\alpha, q), A_x(\beta, q)\} \end{aligned}$$

Hence the theorem

Theorem 5.5 Let G and H be two Γ -semirings and π be a homomorphism of G onto H . If A is a Q -Pythagorean fuzzy bi-ideal of H , then $\pi^{-1}(A)$ is a Q -Pythagorean fuzzy bi-ideal of G .

Proof. Since G and H be two Γ semirings and π be a homomorphism of G onto H . If A is a Q -Pythagorean fuzzy ideal of H .

Then

$$\begin{aligned} \pi^{-1}(A_x(\alpha, q)) &= A_x(\pi(\alpha, q)) \text{ and} \\ \pi^{-1}(A_y(\alpha, q)) &= A_y(\pi(\alpha, q)) \text{ for all } \alpha \in G \\ \text{Let } \alpha, \beta \in G. \text{ The} \\ \pi^{-1}(A_x)(\alpha\gamma_1\eta\gamma_2\beta, q) &= A_x(\pi(\alpha\gamma_1\eta\gamma_2\beta), q) \\ &\geq A_x(\pi(\alpha)\gamma_1\eta\gamma_2\pi(\beta), q) \\ &\geq A_x(\pi(\alpha, q)) \wedge A_x(\pi(\beta, q)) \\ &= \pi^{-1}(A_x(\alpha, q)) \wedge \pi^{-1}(A_x(\beta, q)) \\ \pi^{-1}(A_y)(\alpha\gamma_1\eta\gamma_2\beta, q) &= A_y(\pi(\alpha\gamma_1\eta\gamma_2\beta), q) \\ &\leq A_y(\pi(\alpha)\gamma_1\eta\gamma_2\pi(\beta), q) \\ &\leq A_y(\pi(\alpha, q)) \vee A_y(\pi(\beta, q)) \\ &= \pi^{-1}(A_y(\alpha, q)) \vee \pi^{-1}(A_y(\beta, q)) \end{aligned}$$

Hence Proved.

CONCLUSION

This paper applies the concept of Q -Pythagorean fuzzy sets to Γ -semirings. We present the algebraic structures of Q -Pythagorean fuzzy sets within Γ -semirings. Additionally, we aspire to extend this framework to various other algebraic structures and explore its applications in real-life scenarios in future research endeavors.



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Braces to Heartburn: Does Prolonged Orthodontic Treatment Cause Gastritis – A Cross - Sectional Study

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ABSTRACT

This survey aims to assess the relationship between Orthodontic treatment and Gastritis. One hundred patients undergoing orthodontic treatment for more than 3 months in the age group 18 to 30 years were sent a questionnaire to complete the survey. There is a positive connection between orthodontic treatment and gastritis. Previous studies suggest the impact of orthodontic treatment on weight loss, food habits, negative self-image, and anxiety. Poor eating habits, prolonged intentional skipping of meals, anxiety about physical appearance, and consumption of NSAIDs are contributing factors to Gastritis during orthodontic treatment. Going through orthodontic treatment does not necessarily cause gastritis, however prolonged orthodontic treatment increases the chances of getting gastritis and can worsen existing gastritis.

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INTRODUCTION

Orthodontic treatment aims to provide a healthy bite - improving the appearance and alignment of crooked, protruding, or crowded teeth, thereby enhancing masticatory efficiency, and esthetics contributing to the overall confidence of an individual and their psychological well-being [1]. Fixed orthodontic Appliance (FA) produces a



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variety of tooth movements e.g. Bodily movement, rotation, uprighting, torquing, and intrusion; and are more efficient in treatment as compared to removable appliances. They allow multiple tooth movements and the establishment of normal incisor relationship with both crown and root movement is possible[2] [3]. Since FA is highly advantageous, certain limitations like difficulty in the maintenance of oral hygiene and frequent breakage are ignored. FA is not aesthetically pleasing. Though orthodontic treatment aims for better esthetics in the end, during the course of treatment psychosocial issues of the patients are overlooked[4]. It is established by various researchers that FA treatment causes weight loss[5]. This is due to the prolonged intentional skipping of meals and lack of nutrients in preferred soft food advised due to decreased masticatory efficiency [6]. Weight loss, however, is a characteristic feature of gastritis. Gastritis is the inflammation of the gastric lining which may be due to various factors like stress, genetic conditions, old age, bacterial infection, autoimmune diseases, regular/unsupervised use of NSAIDs, smoking, lifestyle choices, irregular food intake, alcoholism[7] [8]. Several etiological factors of gastritis share a common ground with the habits of patients undergoing orthodontic treatment with fixed appliances[5]. Improper food habits, prolonged intentional skipping of meals [9], regular/ unsupervised use of NSAIDs [10], poor oral hygiene[11], disturbed sleep, and psychosocial stress and anxiety [12] form a bridge between orthodontic treatment and gastritis. This study aims to determine if Prolonged orthodontic treatment precipitates gastritis.

METHODOLOGY

STUDY DESIGN- This was a cross-sectional questionnaire-based study to determine if prolonged orthodontic treatment might precipitate gastritis.

QUESTIONNAIRE- The structured, self-administered questionnaire was partly adapted from comparable studies previously conducted on difficulties of patients undergoing orthodontic treatment and the symptoms of gastritis which were standardized. The questionnaire was circulated in an electronic medium (Google Forms). The responses were collected in April 2023. The questionnaire had 15 questions in total consisting of 3 sections;

- i) Demographic details (name, age, sex, duration of orthodontic treatment)
- ii) Difficulties and habits of patients undergoing orthodontic treatment (5 questions) regarding frequency of food intake, NSAID consumption, sleep disturbance, and social anxiety.
- iii) Symptoms of gastritis (6 questions) regarding weight loss, heartburn, bloating, response to spicy food and antacids, and the consultation of a physician relating to gastric issues after 6 months of orthodontic treatment.

PARTICIPANTS- The questionnaire was circulated among 100 orthodontic patients in Asan Memorial Dental College and Hospital, Chengalpattu.

Inclusion criteria

- i) Patients aged between 18 years to 30 years
- ii) Orthodontic treatment duration more than 3 months

Exclusion criteria

- i) Patients aged less than 18 years of age
- ii) Orthodontic treatment duration less than 3 months

STATISTICAL ANALYSES

Chi-square tests were used to analyze the relationship between the duration of orthodontic treatment, intentional skipping of meals, unsupervised administration of NSAIDs, psychosocial stress and anxiety, burning sensation in the stomach, weight loss, bloating, and the consultation of a physician for gastric issues after orthodontic treatment. Two-tailed analyses were conducted, and P values less than 0.05 were considered significant. The data were statistically analyzed using SPSS v. 24.0 (IBM, Armonk, NY, USA).

NULL HYPOTHESIS – Orthodontic treatment and the occurrence of gastritis are independent of each other.

ALTERNATIVE HYPOTHESIS – Orthodontic treatment leads to gastritis/ worsens existing gastritis severity.



**Lakshmi Ravi et al.,****HOW LONG HAS IT BEEN SINCE THE COMMENCEMENT OF ORTHODONTIC TREATMENT * DO YOU HAVE A BURNING FEELING IN YOUR STOMACH BETWEEN MEALS AND AT NIGHT?**

The cross-tabulation and chi-square tests were conducted to investigate the relationship between the duration since the commencement of orthodontic treatment and the occurrence of a burning feeling in the stomach between meals and at night. The observed counts depict the distribution of responses across different time intervals, while the expected counts are based on the assumption of independence. The chi-square tests reveal a statistically significant association between the duration of orthodontic treatment and the experience of a burning feeling in the stomach (Pearson Chi-Square = 18.415, $p = 0.031$). The linear-by-linear association test suggests a potential linear trend in the relationship, indicating that as the duration of orthodontic treatment increases, the likelihood of experiencing a burning feeling in the stomach also increases. Symmetric measures (Phi and Cramer's V) show a moderate association.

Correlations

The correlation matrix reveals the relationships between various factors related to orthodontic treatment and gastric issues. Here's a brief analysis of the correlations:

Duration of Orthodontic Treatment and Meal Skipping Habits:

Pearson Correlation: 0.232*

Significance: $p = 0.020$ There is a weak positive correlation (significant at the 0.05 level) between the duration of orthodontic treatment and the tendency to skip meals due to fear of breaking brackets or intentionally avoiding favorite foods.

Meal Skipping Habits and Consulting a Doctor for Gastric Issues:

Pearson Correlation: 0.478**

Significance: $p < 0.001$

A moderate positive correlation (highly significant at the 0.01 level) exists between the tendency to skip meals and the likelihood of consulting a doctor for gastric issues after orthodontic treatment.

Burning Feeling in Stomach and Other Variables:

Duration of Orthodontic Treatment: 0.294**

Meal Skipping Habits: 0.568**

Bloating/Flatulence: 0.420**

Medication for Pain Relief: 0.395**

Consulting a Doctor for Gastric Issues: 0.401**

All correlations are highly significant at the 0.01 level.

There are strong positive correlations between the burning feeling in the stomach and various factors, including duration of orthodontic treatment, meal-skipping habits, bloating/flatulence, medication for pain relief, and consulting a doctor for gastric issues.

Bloating/Flatulence and Medication for Pain Relief:

Pearson Correlation: 0.395**

Significance: $p < 0.001$

There is a moderate positive correlation (highly significant at the 0.01 level) between experiencing bloating/flatulence and taking medication for pain relief after orthodontic visits.

Medication for Pain Relief and Consulting a Doctor for Gastric Issues:

Pearson Correlation: 0.377**

Significance: $p < 0.001$

A Strong positive correlation (highly significant at the 0.01 level) exists between taking medication for pain relief and consulting a doctor for gastric issues after orthodontic treatment.



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In summary, the correlations suggest several significant associations. Notably, the duration of orthodontic treatment is weakly correlated with meal-skipping habits, while meal-skipping habits strongly correlate with consulting a doctor for gastric issues. The burning feeling in the stomach is strongly correlated with multiple variables, indicating its potential role in gastrointestinal concerns during orthodontic treatment. Additionally, taking medication for pain relief is moderately correlated with both bloating/flatulence and consulting a doctor for gastric issues.

REGRESSION

Dependent Variable: HAVE YOU CONSULTED A DOCTOR FOR GASTRIC ISSUES AFTER ORTHODONTIC TREATMENT RECENTLY? The regression model aims to predict the likelihood of individuals consulting a doctor for gastric issues after orthodontic treatment. The model's overall fit is summarized as follows:

R Square (Coefficient of Determination): The R Square value of 0.224 indicates that approximately 22.4% of the variance in the dependent variable (consulting a doctor for gastric issues) is explained by the independent variables included in the model.

Dependent Variable: HAVE YOU CONSULTED A DOCTOR FOR GASTRIC ISSUES AFTER ORTHODONTIC TREATMENT RECENTLY?

The analysis of variance (ANOVA) table for the regression model indicates a statistically significant relationship between the predictors and the likelihood of individuals consulting a doctor for gastric issues after recent orthodontic treatment. **Regression Sum of Squares (SSR):** The variation in the dependent variable (consulting a doctor for gastric issues) explained by the predictors is 4.314. The F-statistic (5.433) tests the overall significance of the regression model. The p-value associated with the F-statistic is highly significant ($p = 0.000$), indicating that at least one predictor in the model has a significant effect on the dependent variable. **b. Predictors:** (Constant), DO YOU FEEL BLOATING OF YOUR STOMACH/ EXPERIENCE FLATULENCE?

Dependent Variable: HAVE YOU CONSULTED A DOCTOR FOR GASTRIC ISSUES AFTER ORTHODONTIC TREATMENT RECENTLY? The coefficients of the regression model provide insight into the individual contribution of each predictor to the likelihood of individual consulting a doctor for gastric issues after recent orthodontic treatment. Individuals taking medication for pain relief after orthodontic visit have a positive and significant impact on the likelihood of consulting a doctor for gastric issues (Beta = 0.231, $p = 0.028$). In summary, the medication for pain relief after orthodontic visits appears to be the most influential factor in predicting the likelihood of consulting a doctor for gastric issues.

RESULTS

Association between Orthodontic Treatment Duration and Gastric Issues

The chi-square tests indicate a statistically significant association between the duration of orthodontic treatment and the occurrence of a burning feeling in the stomach between meals and at night ($p = 0.031$). There seems to be a potential linear trend, suggesting that as the duration of orthodontic treatment increases, the likelihood of experiencing a burning feeling in the stomach also increases.

Correlations between Orthodontic Treatment and Gastric Issues

The correlation matrix reveals several significant associations.

- There is a weak positive correlation between the duration of orthodontic treatment and the tendency to skip meals ($p = 0.020$).
- A moderate positive correlation exists between meal-skipping habits and consulting a doctor for gastric issues ($p < 0.001$).
- The burning feeling in the stomach is strongly correlated with the duration of orthodontic treatment, meal-skipping habits, bloating/flatulence, medication for pain relief, and consulting a doctor for gastric issues (all $p < 0.001$).



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- Taking medication for pain relief is moderately correlated with both bloating/flatulence and consulting a doctor for gastric issues (both $p < 0.001$).

Regression Analysis

The regression model, aimed at predicting the likelihood of individuals consulting a doctor for gastric issues after orthodontic treatment, has an R Square of 0.224. This indicates that approximately 22.4% of the variance in consulting a doctor for gastric issues is explained by the included predictors. The ANOVA table shows a highly significant relationship between the predictors and the likelihood of consulting a doctor for gastric issues after prolonged orthodontic treatment ($p = 0.000$). The most influential factor in predicting the likelihood of consulting a doctor for gastric issues is taking medication for pain relief after orthodontic visits (Beta = 0.231, $p = 0.028$).

DISCUSSION

According to Gnanasamandham et. Al, Placement of separators, placement of initial arch wires, adjustments, and activation of orthodontic appliances can cause discomfort and pain for 2-3 days, which decreases by the fifth or sixth day. This pain affects patients' eating pattern. Patients may avoid hard foods and restrict food intake because of the conditioned and nociceptive reflexes elicited by arch-wire activation[5] [17]. According to Ju-Yeon Lee et. Al's case studies, the patients began to display pathological eating pattern and the avoidance of food to reduce the pain associated with braces, but they did not express weight and shape concerns. Although most psychiatric disorders are often intentionally hidden in adolescence, their cases exhibited relatively healthy eating patterns and the maintenance of weight gain until the initiation of orthodontic therapy. However, as orthodontic treatment progressed, patients adopt pathological eating patterns that continued even after their oral pain had reduced[4] [17]. In accordance with our survey 73% of patients had agreed to intentionally restricting meals and avoid the consumption of their favorite food due to pain arising from orthodontic visits and the habits continue even after the pain has subsided, just to avoid the breaking of brackets.

Various researchers like Ajwa et. Al [13], Shalchi et. Al [14], Soni et. Al [15] and Sandeep et. Al [16] have concluded that orthodontic treatment leads to significant weight loss. This is further substantiated by our study, where 65% of patients agree that they have undergone weight loss after orthodontic treatment. According to our study, 47% patients admit to Unsupervised consumption of NSAIDs and it is the most influential factor in consulting a physician for gastric issues ($p = 0.02$). This is supported by previous articles of Roda et. Al [10] and Shalchi et. Al [14]. Makrygiannakis et, Al's Evidence also suggests the negative impact of chronic usage of NSAIDs on the efficacy of Orthodontic treatment and the increase in treatment duration [18]. Hence, it may lead to a vicious cycle where patients regularly consume NSAIDs due to pain caused by orthodontic treatment, and thereby the efficacy is reduced, leading to the prolonged duration of Orthodontic treatment. Ultimately inducing gastric issues in long-term Orthodontic patients. Orthodontic treatment aims to improve confidence and promote the self-esteem of patients, especially in adolescents. However, during the course of treatment, the appearance of patients is overlooked, and the self-esteem level is particularly low and patients are conscious about their smile, and refrain from displaying their teeth in public. This includes Smiling, laughing, and even eating in public places thereby affecting the quality of life in orthodontic patients [5]. According to our study, 60% of respondents agree about feeling anxious and self-conscious about smiling or eating in public. It is established that Chronic stress and anxiety lead to gastritis [19] [20]. According to our study, the correlation of various factors like intentional skipping of meals due to pain caused by orthodontic treatment and fear of braking brackets, unsupervised consumption of NSAIDs for pain management, psychosocial stress, and anxiety ultimately precipitate gastritis on long-standing orthodontic treatment; increasing the likelihood of consulting a physician for gastric issues by 22.4% after orthodontic treatment.





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CONCLUSION

In conclusion, our study underscores a significant association between prolonged orthodontic treatment and the onset of gastric issues. The interplay of poor dietary habits, intentional meal skipping, anxiety, and use of NSAID during orthodontic care emerges as key contributors to gastritis. While orthodontic treatment itself may not be a direct cause, prolonged durations heighten the risk and exacerbate existing conditions.

Addressing these factors is paramount for comprehensive patient care. A holistic approach, incorporating nutritional guidance, psychological support, and vigilant monitoring of medication usage, can mitigate the risk of gastritis during orthodontic treatment. This study prompts a reevaluation of treatment protocols and highlights the need for patient education programs to foster well-being beyond the structural aspects of orthodontic care.

LIMITATIONS AND FUTURE DIRECTIONS

- The sample is limited to a specific age group and a single dental institution, affecting generalizability.
- Future research could explore additional factors contributing to gastritis during orthodontic treatment and consider longitudinal studies for a more comprehensive understanding.
- Clinical interventions and patient education programs may be developed to address the identified risk factors and promote holistic well-being during orthodontic treatment.

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Table:1

			DO YOU HAVE A BURNING FEELING IN YOUR STOMACH BETWEEN MEALS AND AT NIGHT?				Total
			No	Sometimes	Yes	More frequently	
HOW LONG HAS IT BEEN SINCE COMMENCEMENT OF ORTHODONTIC TREATMENT	< 6 months	Count	13	5	2	1	21
		Expected Count	9	5	5.7	1.3	21
	6 – 12 months	Count	21	13	8	4	46
		Expected Count	19.8	11	12.4	2.8	46
	12 – 18 months	Count	4	3	5	0	12
		Expected Count	5.2	2.9	3.2	0.7	12
	18- >24 months	Count	5	3	12	1	21
		Expected Count	9	5	5.7	1.3	21
Total		Count	43	24	27	6	100
		Expected Count	43	24	27	6	100





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Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	18.415 ^a	9	0.031
Likelihood Ratio	18.511	9	0.03
Linear-by-Linear Association	8.547	1	0.003
N of Valid Cases	100		

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	0.429	0.031
	Cramer's V	0.248	0.031
N of Valid Cases		100	

Table 2: Correlations

		HOW LONG HAS IT BEEN SINCE THE COMMENCEMENT OF ORTHODONTIC TREATMENT ?	DO YOU TEND TO SKIP MEALS DUE TO FEAR OF BREAKING BRACKETS / INTENTIONALLY AVOID YOUR FAVORITE FOOD?	DO YOU HAVE A BURNING FEELING IN YOUR STOMACH BETWEEN MEALS AND AT NIGHT ?	DO YOU FEEL BLOATING IN YOUR STOMACH/ EXPERIENCE FLATULENCE?	ARE YOU TAKING ANY MEDICATION TO RELIEVE PAIN AFTER ORTHODONTIC VISIT?	HAVE YOU CONSULTED A DOCTOR FOR GASTRIC ISSUES AFTER ORTHODONTIC TREATMENT RECENTLY ?
HOW LONG HAS IT BEEN SINCE COMMENCE	Pearson Correlation	1	.232*	.294**	0.166	.215*	0.142
	Sig. (2-		0.02	0.003	0.1	0.032	0.158





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MENT OF ORTHODONTIC TREATMENT	tailed)						
	N	100	100	100	100	100	100
DO YOU TEND TO SKIP MEALS DUE TO FEAR OF BREAKING BRACKETS / INTENTIONALLY AVOID YOUR FAVORITE FOOD?	Pearson Correlation	.232*	1	.478**	.261**	.250*	.269**
	Sig. (2-tailed)	0.02		0	0.009	0.012	0.007
	N	100	100	100	100	100	100
DO YOU HAVE A BURNING FEELING IN YOUR STOMACH BETWEEN MEALS AND AT NIGHT?	Pearson Correlation	.294**	.478**	1	.568**	.420**	.401**
	Sig. (2-tailed)	0.003	0		0	0	0
	N	100	100	100	100	100	100
DO YOU FEEL BLOATING IN YOUR STOMACH/ EXPERIENCE FLATULENCE?	Pearson Correlation	0.166	.261**	.568**	1	.395**	.325**
	Sig. (2-tailed)	0.1	0.009	0		0	0.001
	N	100	100	100	100	100	100
ARE YOU TAKING ANY MEDICATION TO RELIEVE PAIN AFTER ORTHODONTIC VISIT?	Pearson Correlation	.215*	.250*	.420**	.395**	1	.377**
	Sig. (2-tailed)	0.032	0.012	0	0		0
	N	100	100	100	100	100	100
HAVE YOU CONSULTED A DOCTOR FOR GASTRIC ISSUES AFTER	Pearson Correlation	0.142	.269**	.401**	.325**	.377**	1
	Sig. (2-tailed)	0.158	0.007	0	0.001	0	
	N	100	100	100	100	100	100





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ORTHODONTIC TREATMENT RECENTLY?							
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*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

Table :3 Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.473 ^a	.224	.183	.3985

Table 4: ANOVA^a

Model	Sum of Squares	df	Mean Square	F	Sig.	
1	Regression	4.314	5	.863	5.433	.000 ^b
	Residual	14.926	94	.159		
	Total	19.240	99			

Table 5: Coefficients^a

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.	Collinearity Statistics			
					B	Std. Error	Beta	Tolerance
1	(Constant)	.677	.146		4.650	.000		
	ARE YOU TAKING ANY MEDICATION TO RELIEVE PAIN AFTER ORTHODONTIC VISIT?	.130	.058	.231	2.238	.028	.776	1.289





Phosphate Solubilising Bacteria; A Promising Approach from Mangrove Forests – A Review

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ABSTRACT

Mangrove forests are one of the unique areas on earth that might be a source for many different species. Mangrove trees stabilise the coast by preventing erosion brought on by storm waves, surges, tides and currents. The size of mangroves ranges from little bushes to large trees. The mangrove ecosystem's apex in terms of microbial richness is still unexplored. The investigation of the microbiological biodiversity in the mangrove ecosystem is one of the most difficult areas of biodiversity research. Plants need phosphate next to nitrogen for their growth and development. Chemical phosphate fertilizers were utilized because plants cannot convert atmospheric phosphorus into phosphate, which has an impact on the fertility of the soil. Phosphate-solubilising Bacteria (PSB) can convert phosphorous into a bio-available form through mineralization and solubilization mechanisms. In order to maintain agricultural expansion and cater the growing human population in a healthy environment, complementary and ingenious alternatives to the current dominance of chemical uses must be developed. The review concentrates on the utilizing PSB as an alternative to commercial phosphatic fertilizers in order to overcome this problem.

Keywords: Phosphate Solubilising Bacteria (PSB), Bioinoculum, Plant growth promotion, Phosphate, Mangrove soils, *Bacillus sp.*, *Xanthobacter sp.*, *Vibrio sp.*, Biofertilizer.



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INTRODUCTION

The mangrove ecosystem is one of the world's most productive coastal ecosystems that are found in tropical and subtropical regions.[1]Because of their high production, quick turnover rates, and constant exchange between terrestrial and marine ecosystems, mangrove trees play a crucial role in the biogeochemical cycling of phosphorus and other nutrients. Phosphorus is a critical and major ingredient in transient zones, such as coastal and estuaries habitats, and it is thought to control the marine productivity during the geological time periods. [2] In the tropics and subtropics of the planet, mangrove forests are the only ones that may be found where land and water meet. Mangroves, which are trees or shrubs, grow most effectively when low wave energy and shelter encourage the sedimentation of tiny particles, which in turn allow these woody plants to produce roots and expand. In comparison to other tropical forests, mangrove forests often include fewer species and have a simpler structural design. Additionally, ferns and scrubby undergrowth are typically absent from them.[3] Mangroves play a critical role in stabilising and protecting the shore from currents, tsunamis and hurricanes in addition to providing a number of ecological services like nesting habitats for migrating birds, and renewable energy sources and serving as a nursery ground for several commercially significant shellfish and shrimp. [4]A varied microbial population that inhabits mangrove ecosystems simultaneously transforms nutrients from decomposing mangrove foliage into sources of phosphorus, nitrogen and other nutrients that can be utilised by plants. In exchange, the bacteria feed on the exudates from the plant. The mangrove ecosystem has certain physical and chemical components that control the quantity and activity of bacteria in the mangrove habitat. Mangrove forests are thriving ecosystems in India that are responsive to climatic changes.[5]

Mangrove Forests

Mangroves have always trapped the heed of scientists and it still confounds the research community to expand the area of research. Mangroves are a diverse group of plants substantially shrubs, palmstrees, and grounds ferns which have acclimatized to the extreme saline conditions between the tides.[6]The specialty of Mangroves is they get adapted to the harsh environment and has the ability to tolerate stress where the other plant species struggle a lot to survive.[7]Although the species diversity of mangrove is inadequate when compared to the terrestrial ecosystems, it has various adaptation abilities to survive and revamp the harsh environment such as high salinity, muddy substrate and strong wind that makes this ecosystem so scathing and crucial for conservation. The largest mangrove cover is located in Asia that has extended over 6.8 million ha and represents about 34-42 % of the world's total area [8] Mangroves are playing a critical role in rendering a large number of environmental benefits, such as buffering the coastlines against cyclones, tsunamis, storms [3]and carbon storage.[9]Kathiresan *et al.*, stated that the Mangroves have a number of essential characteristics that increase their resistance to disturbances caused by anthropogenic and industrial activities as well as natural calamities like climate change and tsunamis. These qualities include the following:

1. A significant source of nutrients and a big reservoir for the biochemical processes.
2. Fast ingestion of nutrients that is already available while utilizing biotic turnover.
3. Effective biotic controls (for instance, high water and nutrient use efficiency)
4. Simple tree architecture enables quick rebuilding and rehabilitation.
5. Redundancy of important species, which may result in the rehabilitation and recovery of the forest's structural and functional elements.[5]

Mangrove forests in India

India is one among the richest countries for mangrove biodiversity in the world, and holds the third position after Indonesia and Australia. [10]India has a long heritage of mangrove forest management. The first mangrove in the world to be put under scientific management is the Sundarbans mangrove, located in the Bay of Bengal (partly in India and partly in Bangladesh).[11]India covers over ~ 4921 sq. km, (Table:1) of the mangrove forests, inhabiting only 3.2% of global mangrove forest. Sundarbans is the largest mangrove cover, occupying 43% and Gujarat has the second largest mangrove cover with 23% of total mangroves in India.[12]



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Microbial Diversity of Mangrove forests

Mangrove habitats' microbial community makeup provides light on their ecological function and special biotechnological potential in the fields of agriculture, industry, medicine, and pharmaceuticals. [14]Fungi cannot solubilize phosphorus as effectively as bacteria can [15]While phosphorus-solubilizing bacteria (PSB) make up 1 to 50% of the total soil microbial population, phosphorus-solubilizing fungi (PSF) only have a 0.1 to 0.5% solubilization capability.[16] The method of analysis utilised when evaluating microbial populations in environmental sample are frequently of its concern. The development of representative colonies from materials served as the foundation for the earliest discoveries of microbial communities. This strategy is still useful for gathering isolates that are easily appropriate for screening for the synthesis of enzymes and other biotechnological uses.[17]

Bacteria

The Sundarbans mangrove ecosystem's phosphorous cycle was discovered to be significantly influenced by soil phosphatase activity and phosphate-solubilizing bacteria. As moved further into the Sundarbans forest ecosystem's deep forest, the amount of soil Phosphatase activity decreased with increase in depth from the dense forest. While soil temperature and pH were found to have a considerable impact on soil phosphatase activity, soil salinity had very little of an impact. This made sure that the phosphate mineralization-related microorganisms in the Sundarbans forest ecosystem are more resilient to salinity variation than to variations in pH and temperature. This ecosystem became a unique source for novel bio and chemo diversity as a result of how the bacterial population developed to create different combinations of enzymes and small chemicals in response to those environmental conditions.[18]

Nitrogen Fixing Bacteria

Zuberer, D *et al.*, stated that the nitrogen fixation is the process by which some bacteria and cyanobacteria transform nitrogen from its gaseous form (N_2) into the mixed forms, such as ammonia or organic nitrogen. Diazotrophs are symbiotic and free-living microorganisms that fix N_2 into proteins.Both terrestrial and marine habitats are capable of supporting the colonisation of nitrogen-fixing bacteria. Insufficient energy sources are expected to constitute a restriction for N_2 fixation in mangrove sediments.[19]Holguin, G *et al.*, explained that, numerous mangrove species have nitrogen-fixing bacteria from the genera *Azotobacter*, *Klebsiella*, *Azospirillum*, *Rhizobium*, and *Clostridium* were isolated from their sediments, rhizospheres, and root surfaces. *V. Aestuarianus*, *Listonellaanguillarum*, *Vibrio campbelli*, and *Phyllobacterium* sp. were among the strains of diazotrophic bacteria that were recovered from the mangrove rhizosphere in Mexico.[20] The diversity of bacterial strains in the Sundarbans silt was discovered by phylogenetic analysis of 16S rRNA gene sequences and were found to be at least eight different bacterial phyla notably *Proteobacteria*, *Planctomycetes*, *Flexibacteria*, *Actinobacteria*, *Gemmatimonadetes*, *Acidobacteria*, *Chloroflexi*, and *Firmicutes* were the major divisions of the discovered bacterial phyla.[21] In Pichavaram's mangrove habitats, N_2 fixing *Azotobacter*, which can be employed as bio fertilizers were widespread.[22]

Phosphate solubilising bacteria

Mangrove plants benefit greatly from phosphate-solubilizing bacteria because they can serve as sources of soluble phosphorus from the soil. Phosphate can be solubilized by certain bacteria that have high phosphatase activity (Table: 2). Nine phosphate-solubilizing bacterial strains, including *Bacillus amyloliquefaciens*, *E. Asburiae*, *Enterobacter aerogenes*, *Bacillus atrophaeus*, *Xanthobacter agilis*, *Paenibacillus macerans*, *Vibrio proteolyticus*, *E. Taylorae* and *Kluyvera cryocrescens* were recovered from the roots of black mangrove (*Avicena germinant*) roots. White mangrove (*Languncularia racemosa*) roots were used to isolate three more strains: *B. Licheniformis*, *Chryseomonas luteola*, and *Pseudomonas stutzeri*. This is the only account of the presence of bacteria from the genera *Xanthobacter*, *Kluyvera*, and *Chryseomonas* in the roots of mangroves and their ability to dissolve phosphate. [23]

Sulfate reducing Bacteria

The aerobic respiration plays a pivotal role in the organic matter degradation in its anaerobic zone, whereas in the anaerobic layer, the sulphate reduction plays an important role in decomposition.[30]Nearly all of the CO_2 emissions from the sediment are attributed to sulphate reduction. Around 53% of the total organic matter could be degraded by sulfate-reducing bacteria found in temperate coastal marine sediment of shallow brackish water in Denmark.[31]



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Desulfovibrio salexigens, *Desulfovibrio desulfuricansaestuariae*, *Desulfovibrio desulfuricans*, *Desulfosarcina variabilis*, *Desulfovibriosapovorans*, *Desulfococcus multivorans* and *Desulfotomaculum orientis* are the species of sulfate-reducing bacteria found in the mangroves of Goa. These strains are nutrient-flexible and can metabolise a variety of simple substances, such as lactate, acetate, propionate, butyrate, and benzoate. These microorganisms may be able to effectively compete for nutrients in the mangrove environment because they may utilise a variety of diverse substrates.[32]Iron and phosphorus availability in mangrove sediments may be influenced by the activity of bacteria that helps in reduction of Sulphate. [33]

Fungi

"*Manglicolous* fungi" are a collection of fungi that habitat in mangrove forests, or mangals. [34] These organisms can produce all the enzymes necessary for lignin, cellulose, and other plant materials' break down which makes them extremely essential for the nutrient cycling in these ecosystems. [35] From 29 mangrove habitats around the world, Hyde K Det al., [36] listed 120 species which included 2 *Basidiomycetes* sp., 87 *Ascomycetes* sp., and 31 *Deuteromycetes* sp. among them. Over a hundred different fungal species have been found in mangrove habitats, The decomposing debris of Rhizophora of South India's Pichavaram contained about 48 different kinds of fungi.[37]

Actinomycetes

Actinomycetes are major producers of antibiotics, anticancer drugs, enzymes, enzyme inhibitors, and immune modifiers, all of which are used extensively in the pharmaceutical industry, forestry sectors and agricultural. They also play a significant part in the natural ecological system.[38] The mangrove ecosystem is a valuable source for isolating actinomycetes that has the capability to produce antibiotics. Beta-unsaturated gamma-lactone, an antibiotic chemical from *Streptomyces grisebruneus*, was isolated and discovered. It exhibited broad anti-microbial action.[39]

Plant and Phosphate

A crucial nutrient for plant growth and crop productivity is phosphorus. Although both organic and inorganic forms of it are plentiful in soils, their availability is limited since they primarily exist in insoluble forms. [40] Phosphate solubilizing microorganisms (PSMs) provide a biological method for making insoluble phosphate to its soluble form so that plants can utilize it.[41] Microorganisms that solubilize phosphate can enhance the growth and productivity of a wide range of crops. PSM inoculation is a promising method for increasing the global food supply without affecting the environment. [16] A crucial nutrient for plant growth and crop productivity is phosphorus. Although both organic and inorganic forms of it are plentiful in soils, their availability is limited since they primarily exist in insoluble forms.[40] Contradictory to the case with nitrogen, there is no significant atmospheric source of a critical growth-limiting nutrient Phosphate (P) that can be rendered biologically available for plants. [42] The characteristics of phosphorus nutrition include crop maturity and production, flower and seed formation, crop quality improvement, root development, stalk and stem strength, resistance to plant diseases and N-fixation in legumes. Over the past decades, although the microbial inoculants have been used to increase soil fertility over the past century, P solubilisation research has been reported on much less frequently than nitrogen fixation.[43] Phosphorus-deficient plants develop slowly and frequently have an unusually dark green colour. Anthocyanin pigments can occur when sugars build up, giving a reddish-purple hue. On low phosphorus areas, this can sometimes be seen in the early spring. Typically, only extremely low phosphorus soils exhibit these symptoms. It should be emphasised that crops may respond well to phosphorus fertiliser without displaying the typical shortages. [44]

PSM's mode of promoting plant growth

Fungi cannot solubilize phosphorus (P) as effectively as bacteria can. [45] The phosphorus-solubilizing fungi (PSF) only have a 0.1 to 0.5% solubilization capability whereas the phosphorus-solubilizing bacterium (PSB) makes up 1 to 50% of the total soil microbial population. [46] Ectorrhizospheric strains of *Pseudomonas* and *Bacilli*, as well as endosymbiotic rhizobia, have been identified in soil bacterial communities as efficient solubilizers of phosphate. [47] Physical-chemical (sorption-desorption) and biological (Immobilization- mineralization) processes define the dynamics of P in the soil. The highly reactive Al^{3+} and Fe^{3+} in acidic soils and Ca^{2+} in calcareous or normal soils, a significant quantity of P provided as fertilizer enters the immobile pools through the precipitation reaction [48,49]



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Phosphate Solubilising Microorganism (PSM) demonstrated the ability to increase the production of deteriorated, ineffective, and barely productive agricultural soils.[48] The main method that PSMs promote the plant growth is by increasing the efficiency with which they take up P that result in their conversion of insoluble form of P into its accessible form (orthophosphate) that plants can use for their metabolism. The solubilization of earlier applied and fixed phosphates in soil is known to be enhanced by PSM inoculation in soil or by coating the seeds for improving crop yield (Table: 3). [50] Additionally, it has been claimed that PSM aid in the absorption of phosphorus from a larger area by expanding the root system's network. High crop yields have been recorded as a result of PSB inoculation, including *Rhizobium*, *Flavobacterium*, *Erwinia*, *Achromobacter*, *Agrobacterium*, *Pseudomonas*, *Micrococcus*, and *Bacillus*. [51] PSMs stimulate the growth of plants by producing phytohormones like auxins, gibberellins, cytokinins and polyamides. [52] PSMs produce antibiotics, hydrogen cyanate (HCN), and antifungal metabolites that help to shield plants from phytopathogens. [53]

Future Trends in the Ecology of Mangrove's Microbial Community

In order to meet the world's demand, the production of chemical phosphatic fertilizers is a very energy-intensive process that annually costs US \$ 4 billion. It has been proposed that the piled phosphates in agricultural soils are sufficient to support the highest crop yields globally for around 100 years. The organisms with the ability to phosphate-solubilize can also transform the insoluble phosphatic compounds in the soil into its soluble forms so that the crops can use them. [58] Research on the function and organization of microbial communities is still in its infancy at the moment. Although there is a lot of information currently available, closing the research gaps will be a difficult task. These sediments are quite complex, and interactions amongst the organisms are very likely. There is still a lack of knowledge of the majority of the microbial groups involved in each stage of the nutrient cycles, as well as how these communities react to local and global environmental changes. A thorough analysis of populations present in various mangroves across the globe is necessary to determine which species or groups of microorganisms are cosmopolitan and which are endemic to a particular region, as well as to evaluate their biotechnological potential. This is one of the most fundamental and first steps in revealing the mangrove's microbial network. [17] It is crucial that scientists and researchers continue to learn about P-solubilizing microbes and translate their understanding into bio-based inoculants that farmers could easily access. Farmers also need to be made aware of the importance of using bio- inoculants as a chance of enabling the sustainable agriculture.

Conflict of Interest

Conflict of Interest declared none.

Abbreviations

- **PSM**- Phosphate Solubilising Microorganism
- **PSB** - Phosphate Solubilising Bacteria
- **PSF** - Phosphate Solubilising Fungi
- **P** - Phosphate

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Table 1: Different types of Mangrove forest distributed along the Indian Coast and their area[13]

S. No	State/ University	Very Dense Mangrove (Km ²)	Moderately Dense Mangrove (Km ²)	Open Mangrove (Km ²)	Total (Km ²)
1	Gujarat	0	182	876	1058
2	Maharashtra	0	69	117	186
3	Andaman and Nicobar Islands	283	261	73	617
4	Daman and Diu	0	0.12	1.44	1.56
5	West Bengal	1038	881	236	2155
6	Puducherry	0	3	1	1
7	Karnataka	0	69	117	186
8	Andhra Pradesh	0	126	226	352
9	Orissa	82	97	43	222
10	Kerala	0	3	3	6
11	Goa	0	20	2	22
12	Tamil Nadu	0	16	23	39
Total		1403	1658.12	1601.44	4662.56

Table: 2 Representing the Sampling places and the microbial isolates

S.No	Country/ Place	Organism Identified	Reference
1.	Odissa, India	<i>Serratia</i> sp.	Behera, B. C et al., (2017)





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			[24]
2.	Laki Island coastal ecosystem	<i>Serratia marcescens</i> and <i>Pseudomonas fluorescens</i>	Widawati, S. (2011) [25]
3.	Indonesia	<i>Klebsiella variicola</i>	Annizah, I. N et al., (2021) [26]
4.	Sub- Tropical Soil	<i>Bacillus megaterium</i> , <i>Phyllobacterium Delftia</i> sp. <i>Arthrobacter ureafaciens</i> , <i>Serratia marcescens</i> <i>Gordonia</i> sp. <i>Chryseobacterium</i> sp. <i>Arthrobacter</i> sp.	Chen, Y. P et al., (2006) [27]
5.	rhizosphere of mangroves	<i>V. proteolyticus</i> , <i>X. agilis</i>	Vazquez, P et al., (2000) [28]
6.	Rhizospheric and Pneumatophoric Sediment of Mangroves	<i>B. atrophaeus</i> , <i>B. amyloliquefaciens</i> , <i>Vibrio proteolyticus</i> , <i>Paenibacillus macerans</i> , and <i>Xanthobacter agilis</i>	Abhijith, R et al., (2017) [29]

Table: 3 Host plants and the type of PSM used in Solubilization

Phosphate Solubilizing Microorganisms (PSM's)	Host Plant	Reference
<i>Azotobacter chroococcum</i> and <i>Azotobacter</i> sp	Wheat	M. Tofazzal Islam et al., 2007 [54] and H. Rodriguez and R. Fraga 1999 [51]
<i>Azospirillum</i> sp.	Sorghum, Maize, and wheat	R. Fraga and H. Rodriguez 1999 [51]
<i>Bacillus</i> sp.	Potato, wheat, Peanut and sorghum	H. Rodriguez and R. Fraga 1999 [51]
<i>Cladosporium herbarum</i> <i>Bacillus megaterium</i> and <i>Bacillus circulans</i>	Wheat	S. Singh and K. K. Kapoor 1999 [55] and M. Tofazzal Islam et al., 2007 [54]
<i>Pseudomonas fluorescent</i> , <i>Pseudomonas chlororaphis</i> , <i>Pseudomonas putida</i> , <i>Pseudomonas fluorescens</i> and <i>Pseudomonas putida</i>	Peanut Soybean Canola, lettuce tomato, Potato, rice, radishes, sugar beet, tomato, apple, citrus, beans, wheat and ornamental plants	M. Tofazzal Islam et al., 2007 [54], Dey, R et al., 2004 [56], H. Rodriguez and R. Fraga 1999 [51]
<i>Mesorhizobium mediterraneum</i>	Barley and chickpea	A. Peix et al., 2001 [57]





Relation between Star Numbers and Triangular, Square and Centred Square numbers

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ABSTRACT

In this paper we have introduced Star numbers and established the connection between Star numbers and well known family of numbers like Triangular numbers, Square numbers, and Centred Square numbers.

Keywords: Star numbers, Triangular numbers, Square numbers, Centred Square numbers.

INTRODUCTION

A figurate number is a number formed by taking points, or dots and arranging them into regular shape, such as a triangular, square, pentagon. Such numbers are called Polygonal numbers or in general, Figurate numbers. Star numbers also falls under the category of Centred Figurate number, where these numbers are represented in Hexagrams shape. In this paper we introduce star numbers and provide results in which star numbers are equal to triangular, square, and centred square numbers.



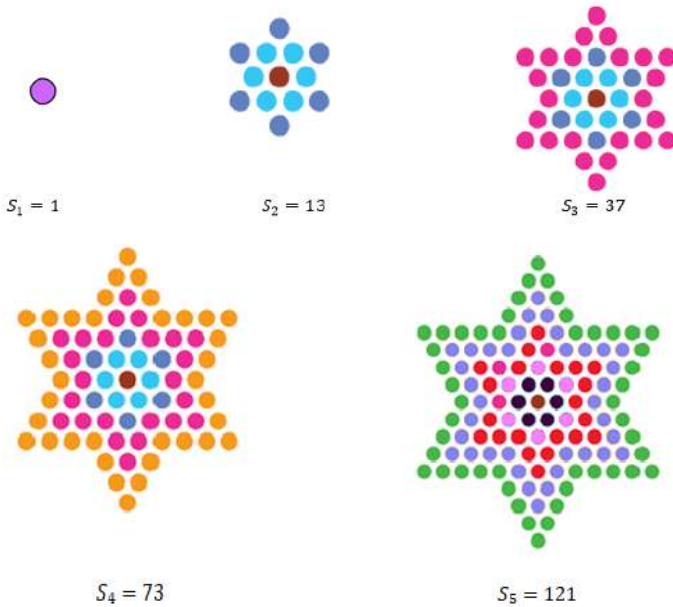


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DEFINITION

STAR NUMBERS

Star numbers are numbers which can be represented in the shape of Centred Hexagrams (six point star). These appear as concentric layers of dots, each layers being arranged in the shape of a hexagram, around a centred dot. The m th star number is defined by $S_m = 6m(m - 1) + 1(1)$. The list of first few star numbers are given by 1, 13, 37, 73, 121, 181, 253, 337, 433, ... Below are representations of the first few Star numbers:



TRIANGULAR NUMBERS

Triangular numbers are numbers that can be represented as a triangle. The first triangular numbers $T_1 = 1$. The second triangular number is found by adding 2 to the previous triangular number and so $T_2 = 1 + 2 = 3$. The third triangular number is found by adding 3 to the previous triangular number and so $T_3 = 1 + 2 + 3 = 6$. The n th triangular number is $T_n = 1 + 2 + 3 + \dots + n = \frac{n(n+1)}{2}$. (2) Below are representations of the first few Triangular numbers:



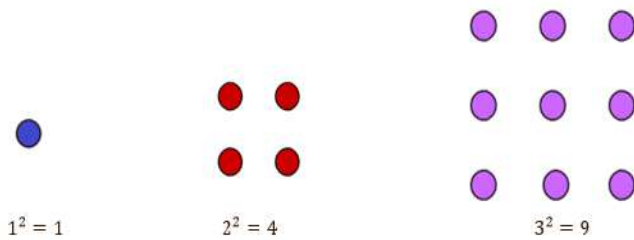
SQUARE NUMBERS

A square number is a number that has been multiplied by itself. It is the product of two equal numbers. $n^2 = n \times n$ (3) Below are representations of the first few Square numbers:





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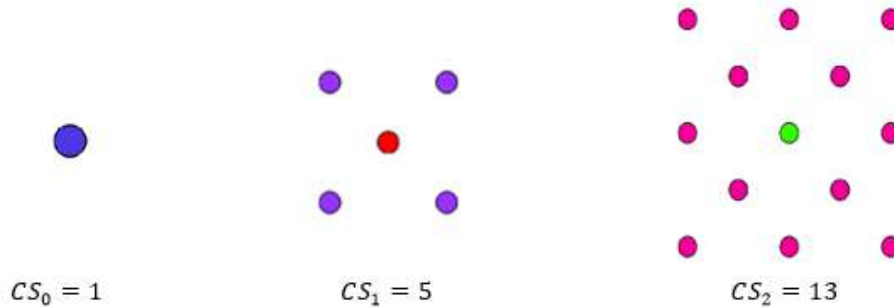


CENTRED SQUARE NUMBERS

A Centred square number is a centred figurate number that represents the number of dots in a square that is centred within in larger square, with a constant number of dots separating the two squares along each side.

The *n*th centred square number is $CS_n = \frac{4n(n+1)}{2} + 1 = 2n^2 + 2n + 1$ (4)

Below are representations of the first few Centred square numbers:



Lemma

Consider the quadratic Diophantine equation $ax^2 - by^2 = c$ (5). Consider $D = ab$. Let (x_0, y_0) be a solution of equation (5) and $u^2 - Dv^2 = 1$ (6).

Then $x = x_0u + b\beta v, y = \beta u + av$ (7) and $x = |-x_0u + b\beta v|, y = |\beta u - av|$ (8) where $\alpha = ax_0, \beta = y_0$ (9) are also solutions of equation (5).

Proof

From the hypothesis, we have $ax_0^2 - by_0^2 = c$. Using (6), (7) and (9), we have $ax^2 - by^2 = a(x_0u + by_0v)^2 - b(y_0u + ax_0v)^2 = u^2(ax_0^2 - by_0^2) - abv^2(ax_0^2 - by_0^2) = (u^2 - abv^2)(ax_0^2 - by_0^2) = 1(c) = c$

Hence the values of x and y from (7) forms solution to (5). Now using (8), we have $ax^2 - by^2 = a(-x_0u + by_0v)^2 - b(y_0u - ax_0v)^2 = u^2(ax_0^2 - by_0^2) - abv^2(ax_0^2 - by_0^2) = (u^2 - abv^2)(ax_0^2 - by_0^2) = 1(c) = c$

Thus the values of x and y from (8) forms solution to (5).

Also we notice that if (x_0, y_0) is one of the solutions to (5), then we can generate infinitely many solutions of (5), using (7) and (8).

In the following section we prove some interesting results.

Theorem 1

There exists infinitely many Star numbers which are also triangular numbers.

Proof: let S_m be the *m*th star number and let T_n be *n*th triangular number.

If $S_m = T_n$ for some m, n then we have





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$$6m(m - 1) + 1 = \frac{n(n+1)}{2} \tag{10}$$

$$n^2 + n - 12m^2 + 12m - 2 = 0$$

$$n = \frac{-1 \pm \sqrt{1^2 - 4(1)(-12m^2 + 12m - 2)}}{2(1)}$$

$$(2n + 1)^2 = 48m^2 - 48m + 9$$

$$(2n + 1)^2 = 3(16m^2 - 16m + 3 + 1 - 1)$$

$$(2n + 1)^2 = 3(4m - 2)^2 - 3$$

$$(2n + 1)^2 - 3(4m - 2)^2 = -3 \tag{11}$$

If we now consider $X = (2n + 1)$ and $Y = 4m - 2$ then (11) can be written as

$$X^2 - 3Y^2 = -3 \tag{12}$$

Comparing with (5), we get $a = 1, b = 3, D = ab = 3,$

One of the solutions for (12) is $(X_0, Y_0) = (3, 2)$

$$\text{Now, consider } u^2 - 3v^2 = 1 \tag{13}$$

$$\text{The continued fraction for } \sqrt{3} \text{ is given by } \sqrt{3} = [1; \overline{1, 2}] \tag{14}$$

The successive convergents obtained from continued fraction of $\sqrt{3}$ are given below

$$\frac{1}{1}, \frac{2}{1}, \frac{5}{3}, \frac{7}{4}, \frac{19}{11}, \frac{26}{15}, \frac{71}{41}, \frac{97}{56}, \frac{265}{153}, \frac{362}{209}, \frac{985}{571}, \frac{1351}{780}, \frac{3691}{2131}, \frac{5042}{2911}, \frac{13775}{7953}, \frac{18817}{10864},$$

$$\frac{51409}{29681}, \frac{70226}{40545}, \frac{191861}{110771}, \frac{262087}{151316} \dots \tag{15}$$

We observe that the numerators and denominators of second, fourth, sixth, eighth, tenth, and so on convergents from (15) forms solution to (13).

$$\text{In particular we observe that the pair of } (u, v) = (2, 1); (7, 4); (26, 15); (97, 56); (362, 209); (1351, 780); (5042, 2911); (18817, 10864), (70226, 40545); (262087, 151316) \dots \tag{16}$$

forms solution to (13).

Now, $(X_0, Y_0) = (3, 2)$ is initial solution to $X^2 - 3Y^2 = -3$

$$\alpha = ax_0 = 3, \quad \beta = y_0 = 2,$$

By lemma (3) we obtain

$$X = x_0u + b\beta v = 3u + 6v \tag{17}$$

$$Y = \beta u + av = 2u + 3v \tag{18}$$

From equations (17) and (18) for every pair of (u, v) given by (16), we obtain the solution of equation (12). Such solutions are given by

$$(X, Y) = (12, 7); (45, 26); (168, 97); (627, 362), (2340, 1351); (8733, 5042); (32592, 18817); (121635, 70226); (453948, 262087); (1694157, 978122) \dots \tag{19}$$

$$\text{Since } m = \frac{Y+2}{4} \text{ and } n = \frac{X-1}{2}, \text{ we have } (m, n) = \left(\frac{9}{4}, \frac{11}{2}\right); (7, 22); \left(\frac{99}{4}, \frac{167}{2}\right); (91, 313); \left(\frac{1353}{4}, \frac{2339}{2}\right); (1261, 4366); \left(\frac{18819}{4}, \frac{32591}{2}\right); (17557, 60817); \left(\frac{262089}{4}, \frac{453947}{2}\right); (244531, 847078) \dots \tag{20}$$

By lemma (3) we obtain

$$X = |-x_0u + b\beta v| = |-3u + 6v| \tag{21}$$

$$Y = |\beta u - av| = |2u - 3v| \tag{22}$$

From equations (21) and (22) for every pair of (u, v) given by (16) we obtain the solution of equation (12). Such solutions are given by

$$(X, Y) = (0, 1); (3, 2); (12, 7); (45, 26); (168, 97); (627, 362); (2340, 1351); (8733, 5042); (32592, 18817); (121635, 70226); \dots \tag{23}$$

$$\text{Since } m = \frac{Y+2}{4} \text{ and } n = \frac{X-1}{2},$$

We have





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$(m, n) \left(\frac{3}{4}, \frac{-1}{2}\right); (1,1); \left(\frac{9}{4}, \frac{11}{2}\right); (7,22); \left(\frac{99}{4}, \frac{167}{2}\right); (91,313); \left(\frac{1353}{4}, \frac{2339}{2}\right); (1261,4366); \left(\frac{18819}{4}, \frac{32591}{2}\right); (17577,60817); \dots$ (24)

Now considering positive and integers values of (m, n) through (20) and (24), we can neglect the repeated values and substituting in (10), we notice that the numbers 1, 253, 49141, 9533161, 1849384153, 358770992581, ... (25) are both Star numbers as well as Triangular numbers.

Theorem 2

There exists infinitely many Star numbers which are also Square numbers.

Proof: let S_m be the m th Star number and let n^2 be n th Square number.

If $S_m = n^2$ for some m, n then we have

$$6m(m - 1) + 1 = n^2 \tag{26}$$

$$6m^2 - 6m + 1 - n^2 = 0$$

$$m = \frac{6 \pm \sqrt{6^2 - 4(6)(1 - n^2)}}{2(6)}$$

$$(12m - 6)^2 = 24n^2 + 12$$

$$(6(2m - 1))^2 = 4n^2 + 2$$

$$6(2m - 1)^2 - 4n^2 = 2$$

$$(2n)^2 - 6(2m - 1)^2 = -2 \tag{27}$$

If we now consider $X = 2n$ and $Y = 2m - 1$ then (27) can be written as

$$X^2 - 6Y^2 = -2 \tag{28}$$

Comparing with (5), we get $a = 1, b = 6, D = ab = 6$

One of the solutions for equations (27) is $(X_0, Y_0) = (2,1)$

$$\text{Now consider } u^2 - 6v^2 = 1 \tag{29}$$

$$\text{Consider } (5 - 2\sqrt{6})(5 + 2\sqrt{6}) = 1$$

$$5 - 2\sqrt{6} = \frac{1}{5 + 2\sqrt{6}} = \frac{1}{10 - (5 - 2\sqrt{6})}$$

$$5 - 2\sqrt{6} = \frac{1}{10 - \frac{1}{10 - \frac{1}{10 - \frac{1}{10 \dots}}}}$$

$$2\sqrt{6} = 5 - \frac{1}{10 - \frac{1}{10 - \frac{1}{10 \dots}}}$$

The successive convergents of the continued fraction expansion of $2\sqrt{6}$ are given by

$$5 \frac{49}{10} \frac{485}{99} \frac{4801}{980} \frac{47525}{9701} \frac{470449}{96030} \frac{4656961}{950599} \frac{46099201}{9409960} \dots$$

Multiplying each of the denominators of the convergents obtained above by 2, the solutions to (29) are given by

$$(u, v) = (5,2), (49,20), (485,198), (4801,1960), (47525, 19402), (470449,192060), (4656965,1901198), (46099201,18819920), \dots \tag{30}$$

By lemma (3), we obtain

$$\text{Now, } (X_0, Y_0) = (2,1) \text{ is initial solution to } X^2 - 6Y^2 = -2$$

$$\alpha = ax_0 = 2, \quad \beta = y_0 = 1$$

$$X = x_0u + b\beta v = 2u + 6v \tag{31}$$

$$Y = \beta u + \alpha v = u + 2v \tag{32}$$

From equations (31) and (32) for every pair of (u, v) given by (30), we obtain the solutions of equation (28). Such solutions are given by $(X, Y) = (22, 9), (218, 89), (2158, 881),$

$$(21362, 8721), (211462, 86329), (2093258, 854569), (20721118, 8459361), (205117922, 83739041), \dots \tag{33}$$

Since $m = \frac{Y+1}{2}$ and $n = \frac{X}{2}$ from (33) we have $(m, n) = (10,11), (45,109), (441,1079), (4361, 10681), (43165, 105731), (427285, 1046629), (4229681, 10360559),$





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$$(41869521, 102558961), \dots \tag{34}$$

By lemma (3), we obtain

$$X = |-x_0u + b\beta v| = |-2u + 6v| \tag{35}$$

$$Y = |\beta u - \alpha v| = |u - 2v| \tag{36}$$

From equations (35) and (36) for every pair of (u, v) given by (30), we obtain the solution of equation (28), such solutions are given by

$$(X, Y) = (2, 1), (22, 9), (218, 89), (2158, 881), (21362, 8721), (211462, 86329), (2093258, 854569), (20721118, 8459361), (205117922, 83739041), \dots \tag{37}$$

Since $m = \frac{Y+1}{2}$ and $n = \frac{X}{2}$ from (33) we have $(m, n) = (1, 1), (5, 11), (45, 109), (441, 1079), (4361, 10681), (43165, 105731), (427285, 1046629), (4229681, 10360559), (41869521, 102558961), \dots$ (38)

Now considering positive values of (m, n) through (34) and (38), we can neglect the repeated values and substituting in (26), we notice that the numbers

$$1, 121, 11881, 1164241, 114083761, 11179044361, 1095432263641, 107341182792481, 10518340481399521, \dots \tag{39}$$

are both Star numbers as well as Square numbers.

Theorem

There exists infinitely many Star numbers which are also Centred Square numbers.

Proof: let S_m be the m th Star number and let CS_n be n th Centred Square number.

If $S_m = CS_n$ for some m, n then we have

$$6m(m - 1) + 1 = 2n(n + 1) + 1 \tag{40}$$

$$2n^2 + 2n - 6m^2 + 6m = 0$$

$$n = \frac{-2 \pm \sqrt{2^2 - 4(2)(-6m^2 + 6m)}}{2(2)}$$

$$(4n + 2)^2 = 4 + 48m^2 - 48m$$

$$(2(2n + 1))^2 = 4 + 48m^2 - 48m$$

$$(2n + 1)^2 = 12m^2 - 12m + 1$$

$$(2n + 1)^2 = 3 \left[4m^2 - 4m + \frac{1}{3} \right]$$

$$(2n + 1)^2 = 3 \left[4m^2 - 4m + 1 - 1 + \frac{1}{3} \right]$$

$$(2n + 1)^2 = 3 \left[(2m - 1)^2 - \frac{2}{3} \right]$$

$$(2n + 1) - 3(2m - 1)^2 = -2 \tag{41}$$

If we now consider $X = 2n + 1$ and $Y = 2m - 1$ then (41) can be written as

$$X^2 - 3Y^2 = -2 \tag{42}$$

Comparing with (5), we get $a = 1, b = 3, D = ab = 3$

One of the solutions for equations (42) is $(X_0, Y_0) = (5, 3)$

Now consider $u^2 - 3v^2 = 1$ (43)

The continued fraction for $\sqrt{3}$ is given by $\sqrt{3} = [1; \overline{1, 2}]$ (44)

The successive convergents obtained from continued fraction of $\sqrt{3}$ are given below

$$\frac{1}{1}, \frac{2}{1}, \frac{5}{3}, \frac{7}{4}, \frac{19}{11}, \frac{26}{15}, \frac{71}{41}, \frac{97}{56}, \frac{265}{153}, \frac{362}{209}, \frac{985}{571}, \frac{1351}{780}, \frac{3691}{2131}, \frac{5042}{2911}, \frac{13775}{7953}, \frac{18817}{10864}, \dots \tag{45}$$

The second, fourth, sixth, eighth, tenth, and so on convergents in (45) forms solution to (43).

In particular we observe that the pair of values $(u, v) = (2, 1); (7, 4); (26, 15); (97, 56); (362, 209); (1351, 780); (5042, 2911); (18817, 10864), \dots$ (46)

forms solutions to (43)

Now $(X_0, Y_0) = (5, 3)$ is initial solution to $X^2 - 3Y^2 = -2$

By lemma (3), we obtain

$$\alpha = ax_0 = 5, \quad \beta = y_0 = 3, \tag{47}$$

$$X = x_0u + b\beta v = 5u + 9v$$





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$$Y = \beta u + \alpha v = 3u + 5v \tag{48}$$

From equations (47) and (48) for every pair of (u, v) given by (46), we obtain the solution of equation (42). Such solutions are given by $(X, Y) = (19, 11), (71, 41), (265, 153),$

$$(989, 571), (3691, 2131), (13775, 7953), (51409, 29681), (191861, 110771), \dots \tag{49}$$

Since $m = \frac{Y+1}{2}$ and $n = \frac{X-1}{2}$ from (49) we have $(m, n) = (6, 9), (21, 35), (77, 132),$

$$(286, 494), (2132, 1845), (3977, 6887), (14841, 25704), (55386, 191860), \dots \tag{50}$$

By lemma (3) we obtain

$$X = |-x_0u + b\beta v| = |-5u + 9v| \tag{51}$$

$$Y = |\beta u - \alpha v| = |3u - 5v| \tag{52}$$

From equations (51) and (52) for every pair of (u, v) given by (46) we obtain the solution of equation (42). Such solutions are given by

$$(X, Y) = (1, 1), (1, 1), (5, 3), (19, 11), (71, 41), (265, 153), (989, 571), (3691, 2131), \dots \tag{53}$$

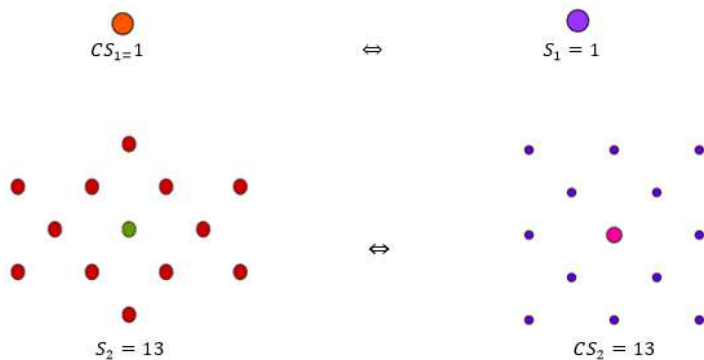
Since $m = \frac{Y+1}{2}$ and $n = \frac{X-1}{2}$ from (53) we have $(m, n) = (1, 0), (2, 2), (6, 9), (21, 35),$

$$(77, 132), (286, 494), (2132, 1845), (3977, 6887) \dots \tag{54}$$

Now considering positive values of (m, n) through (50) and (54), we can neglect the repeated values and substituting in (40), we notice that the numbers

1, 13, 181, 25201, 35113, 489061, 6811741, 94875313, 1321442641, 18405321661, ... (55) are both Star numbers as well as Centred Square numbers.

The Star numbers and Centred square numbers diagram are given below



CONCLUSION

In this paper, after introducing star numbers we have established three theorems related to set of star numbers which are also triangular numbers, square numbers and centred square numbers respectively. The star numbers considered as part of figurate numbers, thus exhibit fascinating connection between other class of figurate numbers. One can try to establish equality of star numbers with other class of interesting sequence of numbers as presented here.

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Pharmacokinetic Profiling and Hepatoprotective Efficacy of Methanol Extract and Bioactive Compounds from Grains of *Pennisetum glaucum* L.

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ABSTRACT

The aim of this study was to evaluate the hepatoprotective efficacy of methanol extract from grains of *Pennisetum glaucum* using rat models. The extract was subjected to GC-MS for phytochemical screening where, **sterols, carbohydrates, phenols, flavonoids, proteins tannins, saponins, and terpenoids were identified**. The total phenolic content and total flavonoid content of the extract are found to be 12.5 mg GAE/g and 62.1 ± 4.17 mg QE/g, respectively in the extract. Acute toxicity tests determined the optimal dosage of MEPG and no symptoms of toxicity or mortality up to a dosage of 2000 mg/kg body weight was noticed. The hepatoprotective effect of methanol extract was assessed using carbon tetrachloride and paracetamol-induced models at doses of 200 mg/kg and 400 mg/kg which demonstrated a significant reduction in CCl₄ and paracetamol-induced liver damage which was confirmed through histopathological studies. Furthermore, the decrease in the levels of serum biochemical markers such as



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ALP, Bilirubin, AST and ALT were also observed indicating a hepatoprotective effect of the extract under study. The results indicate that *Pennisetum glaucum* is an excellent source of phytochemicals and therefore, further studies are needed on various biochemical aspects where the data procured might help in the developments of lead products and formulations suitable for the management of various liver diseases.

Keywords: *Pennisetum glaucum*, Acute Toxicity, Paracetamol, Carbon tetrachloride, Serum markers and Hepatoprotective efficacy

INTRODUCTION

The liver, one of the largest organs in the human system, is crucial due to its oversight of many functions, including metabolism, which is necessary for survival [1]. The organ's position in the human anatomy makes it susceptible to a wide variety of outside toxins. The intestinal absorption of these xenobiotics begins in the liver, making it an organ vulnerable to ailments [2]. An abundance of hepatotoxic agents, including alcohol, viruses, and chemicals such as carbon tetrachloride (CCl₄) and paracetamol, are currently responsible for the poor well-being of countless individuals [3-4]. More than 20,000 people die each year from liver diseases, making it a major health concern around the world [5]. Traditional medicine for liver problems may not be effective enough or may even cause harm [6]. This is the reason why switching from chemical medications to herbal remedies is crucial. As a result, herbal treatments have become widely popular and extensively utilized. A large range of medicinal plants and their preparations around the world have asserted hepatoprotective activity. Research has shown that 101 different plants contain around 160 phytoconstituents that protect the liver [7]. In recent years, there has been more interest in naturally occurring substances from plants, such as phenolic acids, flavonoids, terpenoids, and sterols, because they have a wide range of pharmacological effects, including antioxidant and hepatoprotective activity [8]. India and Africa both rely on pearl millet, scientifically known as *Pennisetum glaucum*, as a mainstay crop in their dry and semi-arid climates. Although it has its roots in the Sahel area of Africa, it has consistently grown in India and Africa since ancient times [9-10]. Despite its humble origins, this cereal has the potential to be a rich source of dietary antioxidants like flavonoids and phenolic acids. These bioactive compounds have been shown to reduce oxidative stress caused by free radicals, which could help prevent ageing and a host of diseases linked to oxidative stress, including cancer, cardiovascular disease, diabetes, asthma, and neurodegenerative disorders [11-12].

Additionally, it controls blood pressure and plasma low-density lipoprotein cholesterol levels and has anti-allergenic properties [13-14]. In light of the foregoing, the current investigation set out to assess the histopathological findings and *in vivo* hepatoprotective effects of a MEPG using paracetamol and carbon tetrachloride-induced models. Acute liver damage can occur from the over administration of paracetamol (acetaminophen), a commonly used antipyretic and analgesic [15-16]. Glucuronide and sulphate conjugates are the primary products of paracetamol's metabolism in the liver [17-18]. But when hepatic cytochrome P450 activates a portion of paracetamol, it forms the extremely reactive metabolite N-acetyl-P-benzoquinone imine (NAPQI), which is responsible for its hepatotoxicity [19-20]. NAPQI can covalently bind to protein cysteine groups, resulting in the formation of 3-(cystein-S-yl) acetaminophen adducts [21]. Glutathione protects hepatocytes by preventing the covalent attachment of paracetamol's reactive metabolite to liver proteins [22]. The CCl₄ is a commonly used poison to induce liver damage in lab animals for experimental purposes [23]. A liver-toxic substance is similar to a virus in that it damages liver cells. When CCl₄ reaches the liver, it is recognised as a xenobiotic. Microsomal mechanisms utilize monooxygenase P-450 to convert it into two free radicals, trichloromethyl and trichloromethyl-peroxyl. These two radicals cause lipid peroxidation, resulting in severe liver damage [24]. Research has shown that antioxidants protect the liver from oxidative damage and reduce the risk of liver disease [25]. Because of this, there is a growing movement to find natural compounds with antioxidant properties and employ them to protect the liver from oxidative stress-related diseases [26].





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MATERIALS AND METHODS

Plant Collection

The *Pennisetum glaucum* grains have been purchased from an authorised millet store in Hyderabad. The material was identified by a botanist in December 2021, and its authenticity was confirmed by the professor and head of the Department of Botany at Government Degree College, Kukatpally, Hyderabad. After rinsing, the botanist crushed the grains into a coarse powder. The material that had been pulverised was kept for the extraction process.

Preparation of Methanolic Extract of *Pennisetumglaucum* (MEPG)

Millet powder (950g) was kept inside the Soxhlet apparatus directly or it is put within a thimble of filter paper. To fix the powder, the methanol is initially siphoned once before boiling. Fragments of activated porcelain were added to the flask in order to prevent the solvent from getting bumped. As soon as the liquid reaches the point of return, it moves the contents of the extractor chamber to the flask, creating a syphon in the syphon tube. When the resulting liquid rises to the top of the extractor's liquid level, the vapours travel via the side tube. To accomplish efficient extraction, one can syphon back and evaporate the solvent in cycles as frequently as feasible without altering it. This technique, which consists just of a few quick macerations, is an ongoing extraction procedure. After drying by evaporation at ambient temperature, the resultant organic extracts were placed in sealed containers for further use.

Phytochemical screening

Preliminary phytochemical analysis was carried out in order to determine the various phytoconstituents present in MEPG.

GC Condition and Identification of Compounds of MEPG

A Scion 436-GC Bruker model equipped with a triple quadrupole mass spectrophotometer and a BR-5MS fused silica capillary column, composed of 5% diphenyl/95% dimethyl polysiloxane, performed the GC-MS analysis. Helium at a flow rate of 1 mL/min was employed as a carrier gas. The ion source is kept at 280°C and the injector at 250°C. The oven was programmed to increase from 200°C to 280°C at a rate of 10°C/min, followed by a further increase of 5°C/min until reaching 280°C. It then maintained an isothermal period of at 280°C with a final hold time of 9 min.

Estimation of total phenolic content

The total phenols present in all the extracts were determined by method described in the literature [27] and in quintuplicate. To an aliquot consisting of 5µL of MEPG, 1M Na₂CO₃ and Folin-Ciocalteu reagent were added. The colour developed after 15 minutes of the reaction in dark was measured at 760nm against reagent blank and gallic acid was served as the reference standard. The total phenols were determined as mg of gallic acid equivalent per gm of sample using a calibration curve.

Estimation of total flavonoids

The total flavonoids were determined with the colorimetric assay using AlCl₃ as published in literature [28] and performed in quintuplicate. To the appropriately diluted extract (200µl), AlCl₃ (10%, 0.2ml), Potassium acetate (1M, 0.2ml) and distilled water (5.6ml) were added. The reaction mixture and incubated for 30 mi. at room temperature. The absorbance was recorded at 420 nm and the total flavonoids were determined using a calibration curve as mg of quercetin equivalent per gm of sample.

Animals

The pharmacological activities were carried out using Wistar Albino rats of either sex weighing 200–250 g and Swiss Albino mice weighing 20–30 g. They were housed in polypropylene cages and subjected to a diurnal cycle with a temperature of 25 ± 2 °C and a relative humidity of 45–55%. Prior to any studies being conducted, the animals were allowed to adjust to the laboratory environment for around one week. Routine animal feed and unlimited water were



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provided to them. Institutional Animal Ethics Committee (IAEC) approval was obtained for all pharmacological experimental protocols.

Acute Toxicity Studies

An investigation was done to find out if the extract was unsafe. The study was conducted in accordance with the OECD. The acute oral toxicity is evaluated using the up-and-down method. An inbred colony of adult Wistar albino rats (weighing 150–200 grammes) is used in this study. The IAEC approved all the experimental pharmacological methodologies.

In vivo Evaluation of Hepatoprotective Activity**Paracetamol Induced Hepatotoxicity**

This seven-day study will involve thirty healthy Wistar albino rats of either sex, weighing between 200 and 250 g. For a duration of seven days, the animals get their subsequent treatment orally. All animals are categorised into five groups of six animals each [29].

Carbon Tetrachloride Induced Hepatotoxicity

This 28 days study will involve thirty healthy Wistar albino rats of either sex, weighing between 200 and 250 g. For a duration of seven days, the animals get their subsequent treatment orally. All animals are categorised into five groups of six animals each [30-31].

Measurement of serum biochemical markers

After 24 hours following the last treatment, blood was collected from the retro-orbital plexus and allowed to coagulate for an hour at ambient temperature, and the serum is then separated by centrifugation at 2500 rpm for 15 mins at 30°C. After separation, the serum was tested for several biochemical factors.

Histopathological examination

Liver tissues were subjected to a photomicroscopy examination after one week of dehydration in a series of ethanol solutions, embedding in paraffin, sectioning into 5 micrometre pieces, and staining with haematoxylin-eosin dye.

ADMET Analysis

ADMET (Absorption, Distribution, Metabolism, Excretion, and Toxicity) analysis was carried out utilising the Swiss-ADME tool. For a compound to be regarded as a therapeutic candidate, the ADMET analysis is deemed too important [32]. Utilising the web-based database pkCSM, the pharmacokinetic scores of substances were assessed.

Statistical analysis

Values were analysed using SPSS 18.0 software and presented as the Mean \pm SD. A one-way analysis of variance (ANOVA) was used, along with the LSD and Dunnett's tests. statistical significance was set to $P < 0.05$.

RESULTS

The *P. glaucum* grains were identified, verified, gathered, desiccated, and ground into powder and the yield of MEPG was found to be 12% w/w.

Phytochemical Analysis

The phytochemicals in the methanolic grain extract of *P. glaucum* showed that it contained flavonoids, steroids, phenols, carbohydrates, tannins, terpenes, fatty acids, proteins, and volatile oils (Table-3).

GC-MS of MEPG

After the GCMS analysis, the subsequent bioactive components in the extract were determined and presented (Table-4).





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Total Phenol and Flavonoid Content

The total phenolic content and total flavonoids content of MEPG were found to be 12.5 mg GAE/gm and 62.1 ± 4.17 mg QE/gm respectively (Fig-2 & 3)

Acute Toxicity Studies

Swiss albino mice showed no signs of toxicity or death up to a dosage of 2000 mg/kg body weight in the experiments. All the animals were found to be healthy, even after fourteen days of surveillance. Consequently, the extract was found to be acceptable up to a dosage of 2000 mg/kg bd.wt.

Dose selection

Results showed that 2000 mg/kg bd wt was safe in the toxicity tests mentioned earlier. The pharmacological studies were conducted using 200 and 400 mg/kg bd.wt. dosages.

In vivo Hepatoprotective Activity

This study set out to test the hypothesis that the MEPG has hepatoprotective effects against CCl₄ and paracetamol-induced hepatotoxicity at varying dosages.

Paracetamol Induced Hepatotoxicity

Paracetamol alone does not cause hepatic damage or drug-induced liver disease. Rather, one of its metabolites, N-acetyl-p-benzoquinoneimine (NAPQI), does. NAPQI directly destroys liver cells and reduces glutathione, the liver's natural antioxidant, leading to hepatic failure. Hepatic toxicity is indicated by elevated levels of various biochemical markers that include total bilirubin, alkaline phosphatase (ALP), alanine aminotransferase (ALT), and aspartate aminotransferase (AST) [33]. The levels of AST, ALP, ALT and bilirubin in the blood were slightly lower in the groups that were given MEPG at 200 mg/kg bd., wt., and 400 mg/kg bd., wt (Table-5). Statistically substantial evidence supported the outcomes. MEPG had an impact on the levels of bilirubin, ALP, ALT and AST (Fig- 4 & 5). The animals given this extract experienced a significant and satisfactory reduction in the research parameters. However, paracetamol-administered mice showed a very significant decrease in liver parameters. The results were given as Mean \pm SEM (n = 6). ANOVA was used for statistical analysis, followed by Dunnett's test. The findings were presented as when compared to control (* = p < 0.0001, ** = p < 0.05), disease control (^A = p < 0.0001), standard (^a = p < 0.0001, ^b = 0.0005, ^c = p < 0.05).

Carbon Tetrachloride Induced Hepatotoxicity

CCl₄, a well-known liver-damaging substance, is frequently used to assess how well drugs generally shield the liver from harm by avoiding liver damage. Acute viral hepatitis and CCl₄-induced liver injury cause similar changes. Following liver metabolism, the conjugates of glucuronide and sulphur can be eliminated [32]. Disruption of the transportation function of hepatocytes results in hepatic injury, causing the leakage of cellular enzymes into the plasma [33]. Damage to the liver's cell plasma results in the release of enzymes from the cytosol into the blood, thereby increasing the enzyme count in the serum. The measurement of serum enzyme levels is a useful quantitative indicator of severity [34]. The treatment groups of MEPG at 200 and 400 mg/kg, bd.wt. (Table-6) exhibited a slight reduction in the serum levels of ALT, AST, bilirubin, and ALP (Fig- 6 & 7). The statistical significance of these reductions was discovered. The parameters were compared between the groups treated with silymarin and CCl₄. The results are given as Mean \pm SEM (n = 6). ANOVA was used for statistical analysis, followed by Dunnett's test. The findings were presented as when compared to control (* = p < 0.0001, ** = p < 0.05), disease control (^A = p < 0.0001), standard (^a = p < 0.0001, ^b = 0.0005, ^c = p < 0.005, ^d = p < 0.001).

Histopathological Studies

The histopathological assessment of the livers in the control, disease control and treatment groups of rats as shown in Fig-8.

- A) **Normal Control:** Hepatic cells with portal, periportal, and centrilobular regions exhibited normal morphology in the liver.



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- B) **Diseased control:** The liver's periportal and centrilobular regions showed multiple focal, tiny foci of hepatocyte necrosis, accompanied by an infiltration of inflammatory cells.
- C) **MEPG (200 mg/kg):** The shape of the area around the port was normal, but the shape of the area in the middle of the lobe had many dead liver cells and lymphocytes moving in.
- D) **MEPG (400 mg/kg):** There was little sinusoidal dilatation between the hepatocytes, but the portal and centrilobular regions showed a normal hepatocyte appearance.
- E) **Silymarin (50 mg/kg):** There was modest sinusoidal dilatation and haemorrhage, but the hepatocytes in the periportal and centrilobular regions looked usual.

DISCUSSION

Chemically driven liver damage, or hepatotoxicity, can result from drug exposure or a spike in free radical levels. Two approaches were used to evaluate hepatoprotective activity: paracetamol-induced hepatotoxicity and CCl₄ inhibition. Overdosing on paracetamol or taking too much of the medicine poses health risks. Paracetamol and its metabolites, NAPQI, are not the primary agents responsible for hepatotoxicity, often known as drug-induced liver injury. NAPQI causes liver failure by destroying liver cells immediately and by lowering the liver's intrinsic antioxidant glutathione. Hepatic toxicity is indicated by a rise in biochemical markers such as overall bilirubin, AST, ALT, and ALP [35]. The groups administered 200 mg/kg bd., wt. of MEPG or 400 mg/kg bd., wt. of MEPG exhibited slight reductions in all measured parameters, including bilirubin, AST, ALT, and ALP. The results showed statistical significance. Meloxicam changed bilirubin, AST, ALT, and ALP levels. After receiving this extract, the animals exhibited a significant and positive improvement in the studied parameters. However, paracetamol caused a dramatic reduction in liver parameter values in mice [36]. The general efficacy of drugs in avoiding liver damage has been measured using the widely known hepatotoxic toxin CCl₄. Similar to the changes caused by acute viral hepatitis, CCl₄-induced liver injury compromises liver function. Following liver metabolism, glucuronide and sulphur conjugates are excretable [37]. The primary indication of liver injury is the release of cellular enzymes into the plasma due to interference with the transport function of hepatocytes [38]. The breakdown of the liver's cellular plasma releases a plethora of enzymes normally found in the cytosol, elevating the serum enzyme concentration. As a quantitative measure of severity, the serum enzyme estimates work well [38]. Serum AST, bilirubin, ALP, and ALT levels in the MEPG treatment groups at 200 and 400 mg/kg, bd.wt., were slightly lower than those in the control groups. A statistical analysis confirmed their significance. We compared the parameters with two groups: one treated with silymarin and another with CCl₄. Liver histology studies in rats administered 200 mg/kg bd.wt. of MEPG revealed some hepatocyte regeneration in the periportal area along with lymphocyte infiltration, but rats administered 400 mg/kg bd.wt. of MEPG exhibited substantial hepatocyte regeneration along with mild sinusoidal dilatation. The GCMS results identified sterols, fatty acids, phenols, flavonoids, vitamins, terpenoids, and linoleic acid, an n-6 polyunsaturated fatty acid. Among saturated fatty acids, palmitic acid is by far the most common, while linolenic acid is an essential omega-3. Linoleic, linolenic, and palmitic acids all help lower oxidative stress and raise serum parameters in liver toxicity caused by drugs. They are also biomarkers of liver damage [39].

The omega-9 fatty acid category includes oleic acid. This fatty acid reduces oxidative stress in rats' liver and spleen by lowering antioxidant levels observed under hepatotoxic conditions [40]. Saturated fatty acids, like stearic acid, have an 18-carbon chain. It is a pentacyclic triterpene that protects the liver by lowering oxidative stress and inflammation-causing substances. It is a pentacyclic triterpene that protects the liver by lowering oxidative stress and inflammation-causing substances [41]. Other types of vitamin E, such as γ -tocopherol and γ -tocotrienol, are better antioxidants than α -tocopherol at protecting against long-term health problems like liver damage caused by drugs. Insufficient solubility in the intestinal fluid may limit the intestinal absorption through the portal vein system to obtain a therapeutic effect when systemic effects are warranted. For oral administration, solubility is a major property influencing absorption. Similarly, a drug meant for parenteral usage has to be highly soluble in water to deliver a sufficient quantity of the active ingredient. The water solubility is critical for the absorption and distribution of drugs within the body, and it ranged from -7.068 to -1.377, and all the readings were within the recommended range, which



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showed the possible good absorption and distribution of MEPG phytochemicals. One important element that determines how effective medications are is their permeability across the blood-brain barrier. It was hypothesised that MEPG phytochemicals had outstanding permeability across the central nervous system. In addition, as these substances are involved in the excretion of drugs, the most frequent isoforms of cytochrome were tested against them. These isoforms inhibit drug interactions. Tocopherol was the only compound that inhibited CYP2C19, while linoleic acid, oleic acid, linolenic acid, arachidonic acid, stearic acid, palmitic acid, lupeol, vanillic acid, campesterol, sitosterol, ergosterol, and indomethacin inhibited the CYP3A4 substrate. In order to determine steady-state concentrations, it is essential to calculate the drug clearance of a chemical. Oleic acid, stearic acid, palmitic acid, arachidonic acid, linolenic acid, and linoleic acid all have sufficient clearance values. Organic Cation Transporter 2 (OCT2) did not recognise any of the substances as substrates. Before a medicine is considered for clinical trials or even in the pre-formulation phase, it must undergo drug toxicity profiling. As a result, the compounds' toxicity has been evaluated. Campesterol, sitosterol, oleic acid, stearic acid, palmitic acid, lupeol, vanillic acid, ferulic acid, tocopherol, indomethacin, and campesterol have all shown hepatoprotective effects.

CONCLUSION

Methanolic extract of *P. glaucum* demonstrated hepatoprotective properties against liver damage induced by PCM and CCl₄ in this investigation. The greater percentage of components like flavonoids and total phenols in the methanolic extract scavenge free radicals, which may explain its hepatoprotective properties. In order to find a new hepatoprotective drug that works well, more research needs to be done to find the pure active principle or principles that protect the liver.

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COMPETING INTERESTS

Authors have declared that there are no competing interests.

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Table 1: Experimental Design for Paracetamol Induced Hepatotoxicity

Groups	Treatment
Group I	Control
Group II	Disease control: Paracetamol (1g/kg bd. wt, p.o., from 1-7days)
Group III	Paracetamol (1g/kg bd. wt, p.o.,) + MEPG (200mg/kg bd. wt.) from 1-7days
Group IV	Paracetamol (1g/kg bd. wt, p.o.,) + MEPG (400mg/kg bd. wt.) from 1-7days
Group V	Paracetamol (1g/kg bd. wt, p.o.,) + Silymarin (50mg/kg bd. wt.) from 1-7days

Table 2: Experimental Design for Carbon Tetrachloride Induced Hepatotoxicity

Groups	Treatment
Group I	Control
Group II	Disease control: CCl ₄ (0.5g/kg bd. wt, i.p., from 1-28days)
Group III	CCl ₄ (0.5g/kg bd. wt, i.p.,) + MEPG (200mg/kg bd. wt.) from 1-28days
Group IV	CCl ₄ (0.5g/kg bd. wt, i.p.,) + MEPG (400mg/kg bd. wt.) from 1-28days
Group V	CCl ₄ (0.5g/kg bd. wt, i.p.,) + Silymarin (50mg/kg bd. wt.) from 1-28days

Table 3: Preliminary Phytochemical Analysis of MEPG

Phytoconstituents	Results
Flavonoids	+
Steroids	+
Phenols	+
Carbohydrates	+
Tannins	+
Terpenoids	+





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Fatty acids	+
Proteins	+
Volatile oils	+

Table 4: Compounds from GC-MS

S. No	Name of the Compound	Molecular Weight	Retention Time (Min.)	Area (%)
1.	Linoleic acid	288.44	22.64	2.14
2.	Glucose	180.56	23.56	7.12
3.	Oleic acid	282.47	22.88	0.19
4.	Linolenic acid	278.43	24.23	0.15
5.	Arachidonic acid	304.47	25.12	0.18
6.	Stearic acid	284.48	26.16	0.17
7.	Palmitic acid	256.40	21.26	0.05
8.	Lupeol	426.72	32.71	0.16
9.	Campesterol	400.68	31.37	0.82
10.	Sitosterol	414.71	32.05	14.04
11.	Ergosterol	396.65	31.95	0.05
12.	Tocopherol	416.68	30.25	0.71
13.	Vanillic acid	168.14	29.80	2.56
14.	Ferulic acid	194.18	27.50	1.98

Table-5: Effect of paracetamol on serum parameters

Groups	Alkaline Phosphatase	Bilirubin	Aspartate Transaminase	Alanine Transaminase
Control	53.0 ± 0.51	0.21 ± 0.02	163.3 ± 0.66	26.3 ± 0.49
Disease control	145.0 ± 0.96*	1.73 ± 0.06*	54.5 ± 0.42*	64.3 ± 0.71*
MEPG (200mg/kg)	73.8 ± 0.60 ^{*Aa}	0.65 ± 0.02 ^{*Ac}	32.1 ± 0.47 ^{*Aa}	55.3 ± 0.88 ^{*Aa}
MEPG (400mg/kg)	63.5 ± 0.42 ^{*Aa}	0.45 ± 0.02 ^{*Aa}	25.3 ± 0.49 ^{*Ab}	44.6 ± 0.88 ^{*Aa}
Silymarin (50mg/kg)	59 ± 0.49 ^{*A}	0.33 ± 0.02 ^{**A}	22.1 ± 0.30 ^{*A}	37.5 ± 0.76 ^{*A}

Table-6: Effects of CCL₄ on serum parameters

Groups	Alkaline Phosphatase	Bilirubin	Aspartate Transaminase	Alanine Transaminase
Control	52.5 ± 0.42	0.23 ± 0.02	15.6 ± 0.33	24.3 ± 0.33
Disease control	153.3 ± 0.50*	2.28 ± 0.04*	63.8 ± 0.47*	73.8 ± 0.47*
MEPG (200mg/kg)	83.5 ± 0.42 ^{*Aa}	0.66 ± 0.02 ^{*Aa}	32.6 ± 0.66 ^{*Aa}	54.1 ± 0.60 ^{*Aa}
MEPG (400mg/kg)	73.5 ± 0.42 ^{*Aa}	0.45 ± 0.02 ^{*Ac}	24.5 ± 0.49 ^{*Ad}	42.0 ± 0.51 ^{*Ab}
Silymarin (50mg/kg)	63.3 ± 0.49 ^{*A}	0.33 ± 0.02 ^{**A}	22.1 ± 0.30 ^{*A}	37.8 ± 0.60 ^{*A}

Table 7: ADME Parameters of the compounds

Compound	Absorption		Distribution		Metabolism		Excretion	
	Water solubility (log mol/L)	Intestinal absorption (%)	VD _{ss} (log L/Kg)	BBB permeability (log BB)	CYP3A4 substrate	CYP2C19 inhibitor	Total Clearance (log ml/min/kg)	Renal OCT2 substrate
Glucose	-1.377	21.51	0.148	-0.943	No	No	0.626	No
Linoleic acid	-5.862	92.329	-0.587	-0.142	Yes	No	1.936	No
Oleic acid	-5.924	91.823	-0.558	-0.168	Yes	No	1.884	No





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Linolenic acid	-5.787	92.836	-0.617	-0.115	Yes	No	1.991	No
Arachidonic acid	-6.042	92.655	-0.644	-0.172	Yes	No	2.102	No
Stearic acid	-5.973	91.317	-0.528	-0.195	Yes	No	1.832	No
Palmitic acid	-5.562	92.004	-0.543	-0.111	Yes	No	1.763	No
Lupeol	-5.861	95.782	0	0.726	Yes	No	0.153	No
Vanillic acid	-1.838	78.152	-1.739	-0.38	No	No	0.628	No
Ferulic acid	-2.817	93.685	-1.367	-0.239	No	No	0.623	No
Campesterol	-7.068	94.543	0.427	0.774	Yes	No	0.572	No
Sitosterol	-6.773	94.464	0.193	0.781	Yes	No	0.628	No
Ergosterol	-6.947	95.197	0.406	0.767	Yes	No	0.564	No
Tocopherol	-6.901	89.782	0.709	0.876	Yes	Yes	0.794	No
Indomethacin	-3.824	98.649	-1.633	-0.563	No	No	No	No

Table-8: Hepatotoxicity profile of Compounds

Compound	Hepatotoxicity
Glucose	No
Linoleic acid	Yes
Oleic acid	No
Linolenic acid	Yes
Arachidonic acid	Yes
Stearic acid	No
Palmitic acid	No
Lupeol	No
Vanillic acid	No
Ferulic acid	No
Campesterol	No
Sitosterol	No
Ergosterol	No
Tocopherol	No
Indomethacin	No

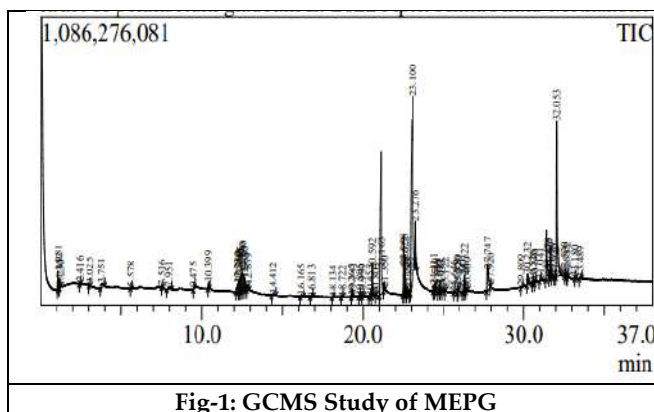


Fig-1: GCMS Study of MEPG

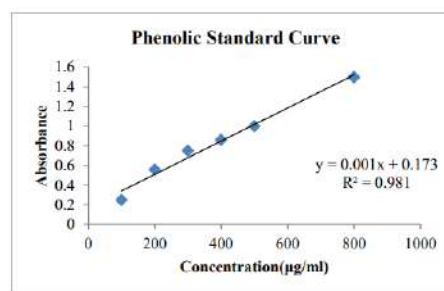


Fig-2: Calibration curve of gallic acid





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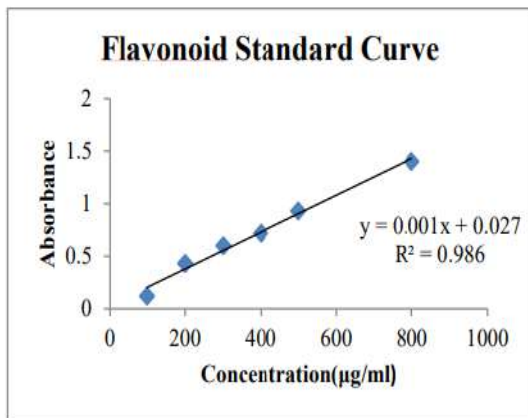


Fig-3: Calibration curve of quercetin

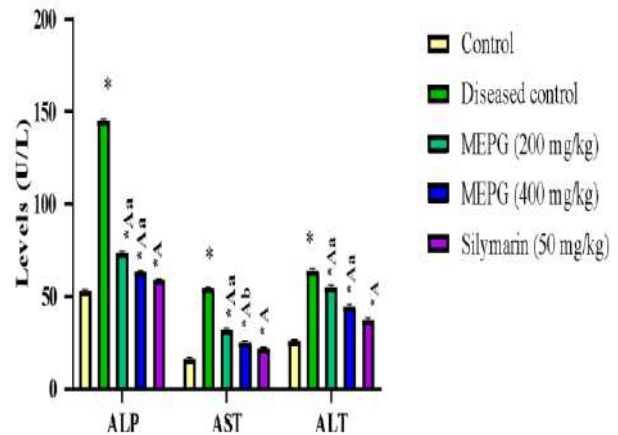


Fig-4: Effect of paracetamol on ALP, AST, and ALT levels

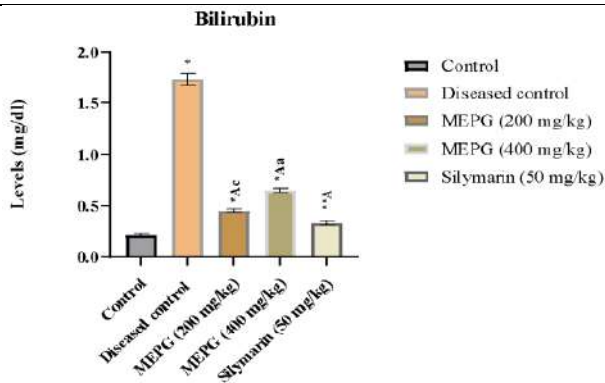


Fig-5: Effect of paracetamol on bilirubin levels

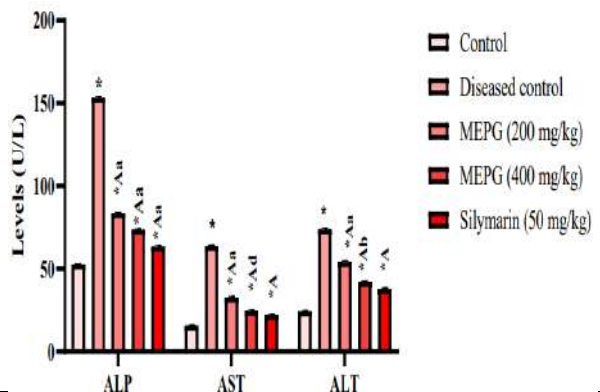


Fig-6: Effects of CCl₄ on ALP, AST, and ALT levels

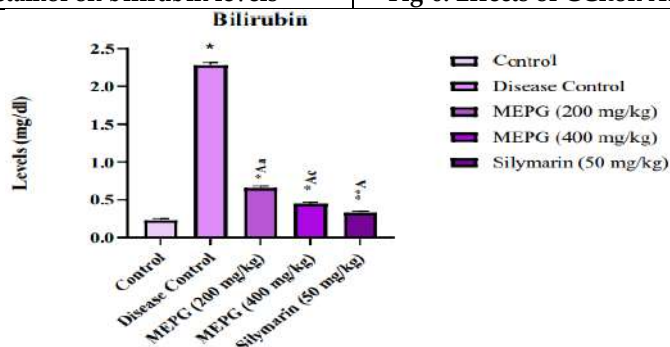
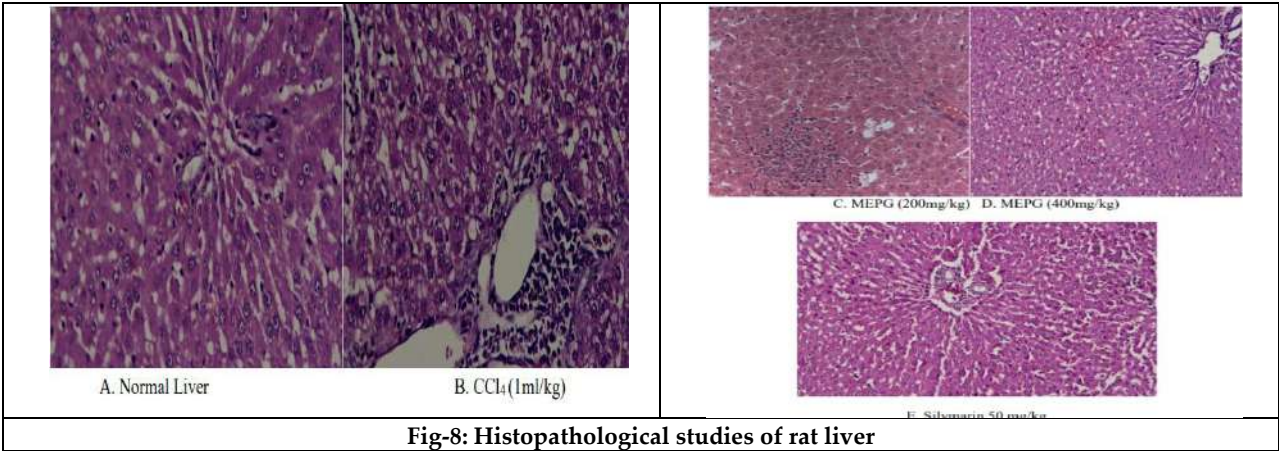


Fig-7: Effect of CCl₄ on bilirubin levels





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Analysis on the LDPE Biodegradation by Microorganisms Isolated from Plastisphere Soil

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ABSTRACT

In this study, bacteria and fungi were isolated and identified from partially degraded LDPE samples, with notable findings including the presence of *Pseudomonas aeruginosa*, *Bacillus* sp., *Aspergillus niger*, *Trichoderma* sp., and *Beauveria bassiana*. These microorganisms were selectively cultured and inoculated in Minimal Salt medium containing LDPE films, leading to a substantial weight loss of 22.17% over a 60-day period under aerobic conditions. *Pseudomonas aeruginosa* exhibited superior degradation capabilities compared to other isolates. Biofilm formation was observed, with significant protein synthesis detected, particularly by *Aspergillus niger*. The observed protein concentrations correlated with the degree of LDPE weight loss. Structural changes in LDPE were confirmed through SEM and FT-IR analysis, highlighting the presence of aliphatic compounds and other chemical alterations indicative of biodegradation. SEM analysis revealed biofilm colonization, cracks, holes, and surface modifications on LDPE films. Overall, this research underscores the potential of microbial biodegradation as an effective and eco-friendly approach for managing plastic waste.

Keywords: Biodegradation, biofilm formation, LDPE, FTIR and SEM analysis.





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INTRODUCTION

Plastic pollution has emerged as a critical environmental concern worldwide, with significant attention focused on the accumulation of plastic debris in every ecosystem [1,2]. Among the various types of plastic polymers, Low-Density Polyethylene (LDPE) represents a major contributor to plastic waste due to its widespread use in packaging and consumer goods[3]. The persistence of LDPE in the environment poses a significant challenge, highlighting the urgent need for effective biodegradation strategies. Traditional methods of plastic disposal include land filling, incineration, and thermal degradation[4,5,6]. Microbial degradation of plastic wastes is an interesting and important strategy to reduce these synthetic polymers without accumulation of toxicity. In recent years, the concept of the "plastisphere" has garnered attention, referring to microbial communities that colonize the surface of plastic debris [7]. Understanding the dynamics of plastisphere microorganisms and their potential to degrade LDPE offers promising avenues for addressing plastic pollution. Bioremediation and biodegradation[8] represent eco-friendly approaches to managing plastic waste, providing safe disposal methods. Researchers have documented the degradation of LDPE by fungi, bacteria, microalgae[9], and other microorganisms. These microbes grow and produce extracellular enzymes that degrade plastics, releasing oligomers and monomers. Fungi, constituting nearly 3% of the plastisphere, play a crucial role in plastic degradation[10]. Various studies have identified plastic-degrading fungi such as *Aspergillus* spp., *Fusarium* spp., and *Penicillium* spp. from the plastisphere [11,12,13]. In this study we aimed to isolate and characterize the microbial colonies that are involved in the biodegradation of LDPE plastic wasted from the plastisphere soil of Tirupattur region, Tamilnadu, India.

MATERIALS AND METHODS

Collection and Isolation of Microorganism

Plastic debris were collected from the waste dump yard sites around Tirupattur district, Tamilnadu, India using sterile techniques to prevent contamination and rinsed using distilled water to remove loosely attached particles and debris. Mineral Salt Medium (MSM) was prepared and the collected samples were inoculated into the MSM.

Preparation of Minimal salt medium

By employing LDPE as the only source of carbon in the growth media, fungi and bacteria that decompose LDPE were cultivated in MSM containing 0.5 g K_2HPO_4 , 0.04 g KH_2PO_4 , 0.002 g $CaCl_2 \cdot 2H_2O$, 0.2 g $(NH_4)_2SO_4$, 0.1 g NaCl, 0.02 g $MgSO_4 \cdot 7H_2O$, 0.001 g $FeSO_4$, and 0.01 g $MnSO_4$. The recovered deteriorated plastics were cultured with the fungus that was taken from the dump yard in a minimum salt media. For the first five days, these culture flasks were incubated at 30 °C with rotation at 160 rpm. The resulting turbid growth and mycelia were purified using Whatman's No. 1 filter paper, then placed on Nutrient agar and SDA plates for analysis of the cultural traits respectively. Subsequently, LB agar plates were prepared and inoculated with the incubated cultures to identify the dominant microbial strain involved in the degradation process [14].

Plate Morphology and Microscopic Identification of fungi

Plate morphology was conducted to determine the fungi on the basis of their color and edges. For microscopic identification, one drop of Lactophenol Blue solution was added to the slide. Fungal culture was emulsified on it. Then, the slide was fixed with a cover slip. The slide was observed under a microscope and fungal isolates were identified on the basis of their hyphae and spores

Evaluation of the LDPE plastic degradation

A second batch of minimal salt medium, enriched with fresh 2 × 2 cm LDPE films, was added to the MSM. Incubation was then maintained for 45 days at regular intervals for biofilm formation analysis. The oxidised LDPE films were collected and treated with sodium dodecyl sulphate (SDS) 2% v/v for 4 hours after 45 days of incubation. SDS was then removed from the LDPE films by washing them in double-distilled water. The pellets were dried in an oven at



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60°C for the entire night to eliminate the adsorbed moisture. A weighing balance with an accuracy of 0.02 mg was used to measure the resulting oxidised LDPE.

Analysis of the physical and chemical parameters of LDPE

The biodegradation of polyethylene (LDPE) was evaluated by surface cracking, weight loss, biofilm formation, decolourisation, chemical alteration and microscopy techniques.

Estimation of proteins on the LDPE samples

The total protein content after incubation was spectrophotometrically estimated by Bradford's method [15]. At 20-day intervals, the PE films were purposely removed from the culture media and gently washed with water to remove any medium debris or loosely adhering cells. The bacterial biomass extracted from the PE film was treated to mild water bath sonication in 1 ml of 0.85% saline for 4 minutes [16]. The resulting saline solution was used to measure protein content at 595 nm using spectrophotometers.

Scanning electron microscopy

LDPE films treated with isolated culture for 60 days were withdrawn from the medium and examined using Field-emission Scanning Electron Microscopy (FE-SEM) to detect biofilm development and surface degradation. The microbial morphology of biofilm on the PE surface was studied after washing the films in 0.01 M phosphate buffer for 2 minutes to remove excess medium adherent to bacterial colonies. To evaluate surface changes, the PE films were washed with 2% SDS and warm distilled water for 10-20 minutes to eliminate bacterial biomass. The polyethylene films were then fixed in 4% glutaraldehyde for 2 hours at 4°C before being dehydrated with 50% ethanol for 30 minutes. The PE films were then incubated overnight in 70% ethanol at room temperature, dried, mounted, and sputter-coated with gold for 40 seconds before being scanned with a SEM.

FTIR analysis of LDPE films

The changes in the treated LDPE was analysed using a PerkinElmer spectrum two FTIR spectrometer. Single or Dual Detector, typically using a deuterated triglycine sulfate (DTGS) detector. The KBR pellets were scanned from the mid-infrared (MIR) range of approximately 4000 cm⁻¹ to 400 cm⁻¹. The degree of biodegradation was determined by analysing the carbonyl index (CI) for specific bonds such as the vinyl bond (VI), ester bond (ECI), internal double bond (IDI) and keto carbonyl bond (KCI).

RESULT AND DISCUSSION**Isolation and identification of Bacteria and fungi**

Following incubation in minimum media and examination under a scanning electron microscope, a large mass of fungal hyphae was found on the surface of the polyethylene film. From the collected partially degraded LDPE samples, a total of 27 bacterial isolates were found and subjected to other parameters including colony morphology, microscopic examination, biochemical character analysis, a total of 5 bacterial samples were found to be promising isolates. The biochemical characters showed the presence of *Pseudomonas aeruginosa* and *Bacillus* sp., from the partially degraded LDPE samples. Among fungi 3 different isolates were found *Aspergillus niger*, *Trichoderma* sp and *Beauveria bassiana*.

Monitoring the LDPE biodegradation

Selectively isolated plastisphere microbes were inoculated in the Minimal Salt medium containing 1% (w/v) LDPE films of 2cmx2cm for 60 days under aerobic condition. During the 60-day incubation period, LDPE experienced a weight loss of 22.17%, with a notable decrease in dry weight particularly in the initial phase (Fig. 1). In contrast, the negative control, lacking inoculation, showed a weight loss of PE microplastic of less than 5%. The variance in weight loss is likely attributed to microbial activity and the partial dissolution of LDPE particles. More predominantly the *Pseudomonas aeruginosa* degraded more of the enriched LDPE film compared to other bacterial and fungal isolates.



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Comparatively all these identified bacterial and fungal strains are found to degrade the all the types of polyethylene materials [17] polyester polyurethane [18] and poly lactic acid [19]. A strong bond by the isolates over the LDPE showed the formation of biofilms with a maximum of 25µg/L concentration by *Pseudomonas aeruginosa* TPT 2 sample (Fig 2.). Among the fungal isolates *Aspergillus niger* synthesised maximum protein with 20 µg/L concentration which is higher compared to other fungal isolates. The overall results of the protein concentration of all the tested isolates followed a pattern similar to the average weight loss of LDPE after the 60 days of incubation. Sathiyabama *et al.* [20] studied the protein concentration in the LDPE biofilm formed by *Cladosporium sphaerospermum* isolated from plastisphere region showed 20.67 ± 0.29 µg/ml of protein. In majority of the research reports the fungi are known to produce the hydrophobic proteins that binds strongly to the LDPE surface [21] and generation of degrading enzymes using their hyphae to extend and penetrate all over the LDPE polymer [22]. Both bacterial and fungal strains were found to be effective in colonizing the LDPE surface. This helped explain the sustained biodegradation of polyethylene through weight loss. Additionally, the degradation was confirmed through SEM and FT-IR analysis.

The FTIR spectrum of the tested LDPE plastic showed significant differences compared to the control LDPE sample (Fig 3.). FTIR analysis can identify changes in the structural and functional groups, potentially elucidating the reasons for weight loss observed in the LDPE film. This technique allows for the detection of alterations in chemical composition that may be associated with the degradation or modification of the LDPE material. The peaks at 2922 cm^{-1} and 2854 cm^{-1} indicated C-H stretches are asymmetric and symmetric stretches respectively of aliphatic hydrocarbons, suggesting the presence of a large quantity of aliphatic compounds. Peaks at 3419 cm^{-1} and 2854 cm^{-1} indicated O-H and C-H bonds in alcohols, phenols, and alkanes that correlates to CH₂ symmetric deformation. Peaks at 732 cm^{-1} and 720 cm^{-1} corresponds to CH₂ rocking deformation. The shifts in peak positions, decrease in peak intensity, and appearance of new peaks suggest that biodegradation have occurred. Similar results have been observed in many results with same peaks and stretches of deformation in the treated LDPE films [23,24,20]. Scanning electron microscopy was also used to investigate the plastics after mechanically detaching the biofilms (Fig 4.). SEM results showed the formation of cracks and holes in oxo-biodegradable plastics. The maximum growth observed in the *Pseudomonas aeruginosa* TPT 3 cultivated LDPE film and that was analysed. In the SEM analysis of cracks, damaged layers, fragile Ness, depth pits and coarsening of the surface and grooves were significantly noted in the treated sample, whereas the surface of the control or the untreated LDPE was mostly smooth. Puglisi *et al.* [25] documented a complex biofilm colonization of various PE plastics, observing cell morphologies, gel matrixes, and hyphal-like structures. Subsequently, following cell detachment, different polymers showed partial degradation with cavities and holes. These biofilms on PE aligned with SEM analyses that had been previously conducted on plastic waste from aquatic environments.

CONCLUSION

The analysis of LDPE biodegradation by microorganisms isolated from plastisphere soil underscores the potential of these microbial strains in degrading polyethylene plastics. Overall, this study highlights the importance of microbial-mediated biodegradation as a sustainable and eco-friendly approach to addressing plastic pollution, offering valuable insights into the mechanisms and potential applications of microorganisms in plastic waste management. Future research in this area can further advance our understanding of microbial degradation processes and contribute to the development of effective bioremediation strategies for plastic waste disposal.

ACKNOWLEDGEMENT

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CONFLICT OF INTEREST

Authors declare no conflict of interests.





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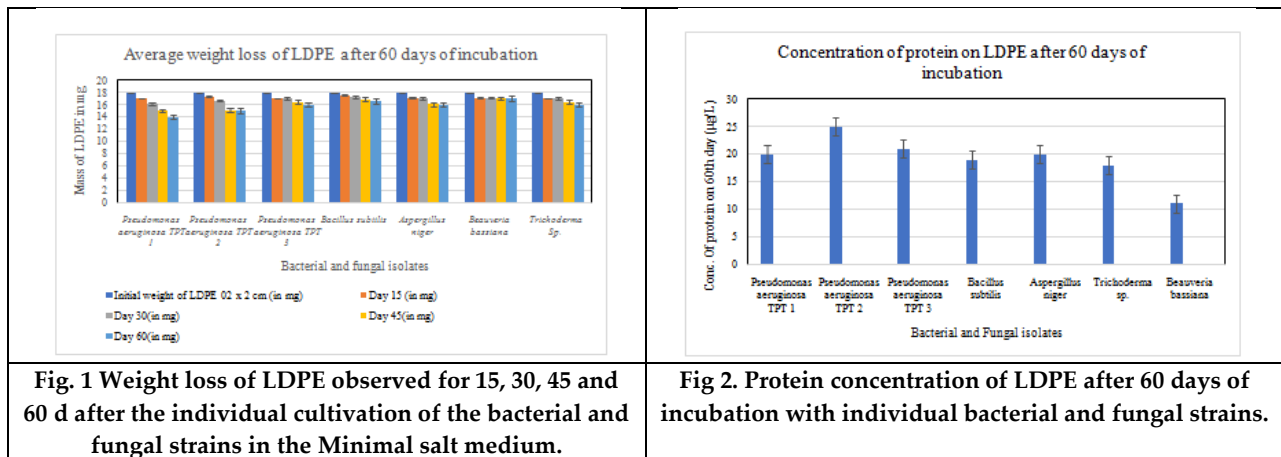


Fig. 1 Weight loss of LDPE observed for 15, 30, 45 and 60 d after the individual cultivation of the bacterial and fungal strains in the Minimal salt medium.

Fig 2. Protein concentration of LDPE after 60 days of incubation with individual bacterial and fungal strains.

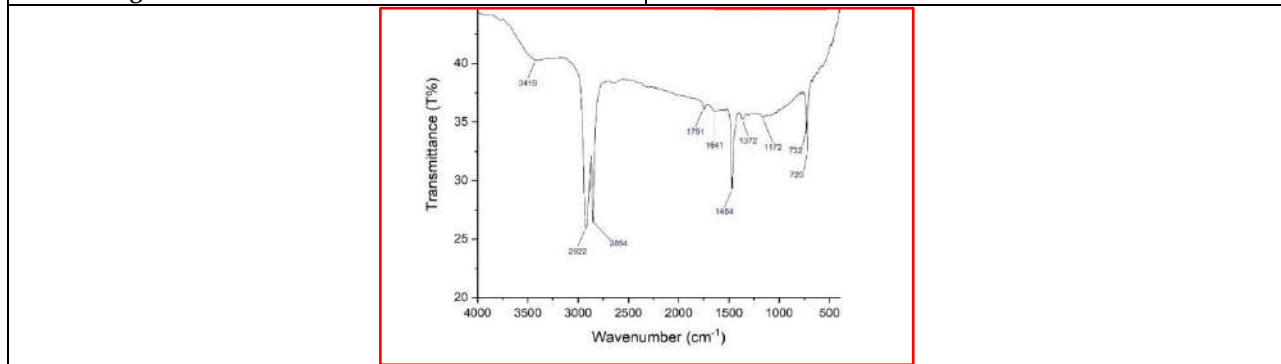


Fig 3. FTIR spectrum of the *Pseudomonas aeruginosa* TPT 2 treated LDPE





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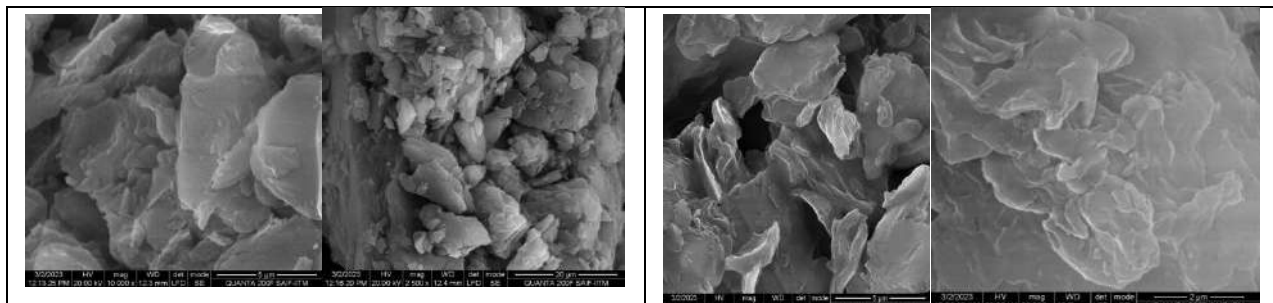


Fig. 4 Scanning electron microscope images of LDPE cultivated in MSM after 60 days of incubation (a, b, c and d – the magnified surface of the LDPE films).





Extraction of Oils from Microalgae using Solvent Methods

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ABSTRACT

Microalgae represent a promising and sustainable resource to produce bio-based products due to their ability to grow in various environments and their capacity to produce a wide range of valuable compounds. Among these compounds, oils extracted from microalgae have garnered significant attention for their potential applications in biofuel production, pharmaceuticals, and nutraceuticals. Potential applications of microalgae-derived oils are vast, ranging from biofuels to high-value omega-3 fatty acids. Additionally, microalgae oils are rich in essential fatty acids, antioxidants, and other bioactive compounds, making them attractive for use in dietary supplements and functional foods. Despite the potential benefits, several challenges remain in the commercialization of microalgae-derived oils. These include the need for cost-effective cultivation and extraction technologies, the development of strains with enhanced oil productivity, and the establishment of sustainable supply chains. Addressing these challenges through continued research and innovation will be crucial for realizing the full potential of microalgae as a source of renewable oils for various applications.

Keywords: Microalgae Antioxidants, Lipids, fatty acids





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INTRODUCTION

Microalgae are simple unicellular or multicellular organisms which usually thrive in freshwater or marine environments. Their wide range applications and research areas include environmental management, biotechnology, biofuels, food production along with their significant role in our ecosystem which today is of a major concern. Microalgae are defined to be a widespread group of species, each with its own characteristics, yet has several things in common. Cell sizes for microalgae typically range from a few micrometres to a few hundred micrometres. Microalgae, like plants, are photosynthetic organisms that use light to turn carbon dioxide and water into organic compounds, primarily glucose. In this process, oxygen is released into the environment. Microalgae possess wide range of pigments, including chlorophyll, which gives them their green colour, as well as various other pigments including red, brown, blue, and yellow. Unsaturated fatty acids are abundant in the lipid fraction of many microalgal species, they add significant nutritional value and contains anti-inflammatory and antioxidant effects. In addition to lipids and pigments, various microalgal biomolecules including phenolics are also under research. Studies are now going on in flavonoids, sterols, and tocopherols and have increased recently due to their anti-inflammatory, antibacterial, and antioxidant properties[12]. High amounts of useful lipids are produced by *Nannochloropsis gaditana*, according to reports. It has a significant number of triglycerides and polar lipids, including phospholipids and glycolipids. Microalgae can accumulate substantial quantities of EPA, and polar lipids are crucial structural and functional elements of the cell membrane. [66] Microalgae could produce equivalent amounts of oil on a smaller scale than other crops, and their predominant fatty acid composition is that of C16 and C18 fatty acids, which make up most vegetable oils[34]. Some species are also abundant in beneficial omega-3 along with polyunsaturated fatty acids (PUFA) comprised with cardiovascular advantages and antioxidant activities.

In addition, they also contain various therapeutic components like sterols and pigments. Consequently, algal oil is viewed as a type of useful oil that has excellent commercial potential. Meanwhile, microalgae can experience certain circumstances due to which it produces a lot of protein, carbs, and other nutrients. Consequently, the algal cooking oil and other co-products could be made from biomass, adding value in the production of oil [34]. Subcritical organic solvent extraction is technology that is simpler to use and far less expensive to produce than conventional organic solvent extraction technology[11]. According to [48] Lipid extraction, conversion, harvesting, and culture are the four main processes involved in the production of biodiesel from microalgae. As a source of third-generation biofuel, microalgae are very favourable since they grow quickly, requires minimal area for cultivation, has shorter generation time, do not require pesticides, and contains high fat content, [62]. Based on Nile red fluorescence microscopy screening, eight outstanding lipid-producing strains were chosen for additional investigation. The taxa *Chlorella* sp., *Neochloris* sp., and *Chlamydomonas* sp. were recognised in the microalgal isolates through sequencing of the 18S rRNA gene is a morpho-taxonomic and molecular method. In terms of specific growth rate and doubling time, *Chlorella vulgaris* PH2 exhibited the highest (μ) and shortest (μ) values with 0.24 and 2.89 0.05 days, respectively [62]. The microalgal oils contained saturated fatty acids (SFAs), polyunsaturated fatty acids (PUFAs), and monounsaturated fatty acids (MUFAs) as their fatty acids. Palmitic acid constituted the major SFA. Oleic acid, linoleic, and linolenic acids were the main components of MUFAs and PUFAs respectively.

The important fatty acid -linolenic acid (ALA), which is found in some strains, was particularly abundant and was greater than 20% of the fatty acids in some strains. [13] Lipids found in microalgae are useful in the production of biodiesel. Under a fluorescence microscope, Nile red staining can be used to find intracellular neutral lipids. In addition to lipid productivity, the fatty acid content plays a significant role in selecting the best microalgal strains for the manufacture of biodiesel [64]. Microalgae have been seen to store significant quantities of neutral lipids and carbohydrates that can be used to make biofuels when under stress. The biochemical composition of a microalgae cannot be measured on-line since it is a very challenging task [2]. Microalgae are responsible for 40% of the world's carbon emission and is estimated to hold up to 70% of dry weight in its oil. Thus, it is useful to make biofuels in turn which could help in reducing greenhouse gas emissions. Except for some microalgae which can withstand harsh environmental conditions





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like high pH example (*Spirulina* sp.) and high salinity (*Dunaliella* sp.) or which grows very quickly like (*Chlorella*, sp.) in open tanks. Closed photobioreactor systems are best suited for some microalgae which can have rapid microbial contamination[9]. Using techniques including mechanical pressing, solvent extraction, and supercritical fluid extraction, oil is recovered from the dried algae. While fatty acid extraction is aided using solvents including n-hexane, benzene, ethanol, chloroform, and diethyl ether, mechanical pressing recovers about 75% of the oil from the harvest. Roughly 95% of the oil may be obtained with the help of n-hexane compound[10]. Microalgae-derived fuels have recently been termed photosynthetic biofuels or algal biofuels to distinguish them from plant oils or cellulose-derived fuels. [66] PUFAs are essential nutrients that must be obtained from outside sources since the organism cannot make them. PUFAs are well-known to include 3 fatty acids. Fish oil is the most renowned and popular source of PUFAs. Fish, on the other hand, does not create PUFAs but rather amass them by means of eating algae (or various algae-eating creatures). It is algae that provide these essential nutrients. Since its establishment in the previous 10 years, PUFA manufacturing from algae has offered benefits including reduced risk of chemical contamination, better purifying potential, and the absence of fish odour[13]. It is widely acknowledged that polyunsaturated fatty acids (PUFAs) are critical for regulation of membrane fluidity, electron and oxygen transport, heat adaptation capacity, and cellular and tissue metabolism. They also prevent obesity and cardiovascular diseases. [13] Microalgae biofuel is non-toxic and extremely biodegradable; it contains no sulphur, and the materials left behind after collecting the oil can be utilised to make ethanol or as soil fertiliser.

Two conversion procedures are used to valorize biodiesel, a liquid fuel made from algal lipids, are undergone transesterification and thermochemical conversion. and thermochemical conversion. The biomass from algae biodiesel can be utilised to absorb damaging greenhouse gases from the atmosphere, and as a fuel that is carbon neutral, it can substantially replace traditional petrol.[18]The fascinating process known as microalgal biofilms encourages microbial cell attachment in an exopolysaccharide matrix with water, producing excess biomass that can be cheaply and readily separated and are utilised to produce a wide range of biofuels or medicines. These biofilm microalgal communities are also very good in eliminating radioactive elements and heavy metals through surface adsorption, intracellular absorption, or precipitates of phosphates or sulphides. A variety of metal ions, including Cd, Pb, Hg, As, Cr, Fe, and others, have been found to adsorb on their surface or intracellularly[19] The biological activity of PUFAs found in microalgae was extensively studied and has a good influence on animal health. Also, microalgal products were tested as feed for animals and fisheries in various forms. *Spirulina*, *Chlorella*, *Lobosphaerainci sa*, *Isochrysis* sp., *Schizochytrium* sp., *Phaeodactylum* sp, *Nannochloropsis* sp, and other microalgae are widely administered.[20]Conversion of raw biomass using trans-esterification is another viable alternative to traditional solvent extraction. The method is based on promoting cell lysis, which liberates intracellular components of microalgae. This process is accomplished by processing the biomass *in situ* using enzymes (cellulase) and acid or basic hydrolysis. The main constituents of microalgal bio-oil are aliphatic (alkanes), fatty acids, phenolics, aromatics, N-containing compounds (such as pyrroles, nitriles, and amides), alcohols, sugars, furans, and acetic acid. This contrasts with lignocellulosic biomass-derived bio-oil. [51]

Microalgal Metabolites

Microalgal proteins have drawn a lot of focus in recent trends. The biomass contains 40-60% of proteins that have major properties that make them suitable food and feed alternatives. Microalgae have received more attention than macroalgae due to its high dietary value, protein and amino acid profile. Microalgal species with high protein content of 50% or higher, such as *Aphanizomenon* sp., *Chlorella* sp., *Dunaliella* sp., and *Arthrospira* sp., are used for human consumption. Marine algal polysaccharides (MAP) offer enormous industrial and new product potential. They are employed in the global market as nutraceuticals, cosmetics, medicines, drug delivery systems, fertilisers, and aqua feeds. The expense and productivity of the enzymatic valorisation process, on the other hand, can be boosted by using technologically useful platforms like combined biomass processing, biorefining, and so on.[18]Super foods from algae are reported to have anti-cancer and anticoagulant activities apart from its role as a buffer in the human body. Algae are a reserve of secondary metabolites that are produced in the log phase. Both freshwater and marine algae produce substantial amounts of secondary metabolites, such as carotenoids, polyphenols, and sterols. [18] The nutritional importance of algal components is significant enough to substitute



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animal-based Aquaculture's sources of lipids and proteins. The secondary pigment known as algal carotenoid has medicinal properties. Among the several classes of carotenoid compounds, β -carotene and astaxanthin contain immense potential as anti-tumour, anti-inflammatory medicines, and treats for metabolic diseases, gastric ulcers, and so on. Omega-3 Fatty acids are recovered from C20:5 ω 3 and C22:6 ω 3 which are polyunsaturated fatty acids. They can be produce food, nutritional fodders, and medications. Omega-3 has been linked to variety health benefits, including the prevention of cardiovascular diseases, cancer, and high blood pressure. Furthermore, omega-3 containing FAs have been shown to help control depression and stimulate animal growth. It has been revealed that human consumption of omega-3 fatty acids is lower than what is advised. As a result, the utilization of microalgal lipids for fatty acid enriched diets and production of nutraceutical supplements is of great interest.

Photobioreactor

The photobioreactor (PBR) is a unique kind of high-tech microalgae culturing reactor used for cultivating microalgae in a range of environments with the help of compatible microalgae strains by utilising light intensity. Solar, artificial (using a fluorescent lamp or another form of light source), or a system that combines both types of light sources, could all be used as the source of light.

***Nannochloropsis* sp.**

Nannochloropsis sp. has received a lot of attention because of its potential applications in wide range of industries, such as biofuel production, aquaculture, and bioremediation. One of the main points of interest is its oil composition, notably its high lipid content. *Nannochloropsis* sp. is recognised for having a high lipid (oil) content that can range between 20% and 50% of its dry weight. Because, the oil collected from *Nannochloropsis* sp. may be turned into biodiesel using techniques such as trans-esterification, it is a prospective candidate for biofuel production. The fatty acid composition of *Nannochloropsis* sp. oil is also noteworthy. Depending on the external conditions, the chemical makeup varies, but the formula usually includes of a blend of Unsaturated fatty acids (UFAs) and saturated fatty acids (SFAs) Because UFAs have better cold flow properties than SFAs, they are recommended for biodiesel synthesis. Examples of these are omega-nine and omega-six fatty acids. Omega-3 Fatty Acids was widely acknowledged that *Nannochloropsis* sp. contains EPA and DHA, two types of omega-3 fatty acids. These are widely used as food supplements because of their curative properties.

Cultivation and Oil Accumulation

Open ponds, closed photobioreactors, and raceway ponds are some of the practises used for growing *Nannochloropsis* sp. The growth conditions, which include light intensity, temperature, CO₂ concentration, and the availability of nutrients (nitrogen and phosphorus), all have a significant impact on the hydrocarbon and triglyceride composition of the microalgae. After culture, the microalgae biomass must be collected and the oil is extracted. To separate the oil from the biomass, various processes such as mechanical pressing, solvent extraction, and supercritical fluid extraction can be used. *Nannochloropsis* has potential applications in aquaculture as a feed additive, the cosmetics industry for producing skin-care products, and bioremediation to remove pollutants from water, in addition to biofuel generation.

Wider Prospectives

Nannochloropsis sp. is a helpful model organism for research and instruction in a various domains, including biology, ecology, biotechnology, and environmental science. Because of its bioactive components, *Nannochloropsis* sp. extracts may have medicinal applications, including as the Development of drugs and treatments. *Nannochloropsis* sp. extracts are used in the cosmetics and skincare industries for their possible antioxidant and anti-ageing qualities. They may aid to protect the skin from free radicals and UV radiation damage. *Nannochloropsis* sp. has the potential to absorb and collect heavy metals and other contaminants from water, soil, and wastewater. This makes it useful for bioremediation process, as it aids in the removal of toxins and pollutants from various habitats.



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Algae supply is used in medications, immunizations, and nutrient enriching supplements that would otherwise be not in use or overpriced to generate using plant and animal sources. Most of the algae discussed in this section are highly advanced or useful in nature. For example, the most important chemical in *Chlorella* sp. from a medicinal standpoint is callose, which is a powerful immunostimulatory, oxygen-based Radical, and aid in the reduction of blood cholesterol. This chemical has been proven to be effective against ulcers, wounds, constipation, as well as prevents atherosclerosis. It reduces hypercholesterolemia and exhibits anticancer properties. Microalgae are a reserve of all necessary vitamins (for example, vitamin A, vitamin B1, vitamin B2, vitamin B6, vitamin B12, vitamin C, vitamin E, niacin, vitamin H, dihydrofolate, and vitamin B5). In addition, microalgae sulphated polysaccharides can also be used in therapy against bacterial infections in both homeotherms and poikilotherms.

Antimicrobial Properties of Microalgae lipids

Antimicrobial properties of microalgae are determined using AWDA that is Agar well diffusion assay. Antibacterial studies showed that ethyl acetate and methanolic extracts contain antibacterial effects on both gram-positive and gram-negative bacteria. Minimum inhibitory concentration (MIC) and Minimum bactericidal concentration (MBC) are also evaluated against bacterial strains. Methanolic extracts of 8 variants of seaweeds were concluded to be highly effective compared to ethyl acetate extracts. The methanolic extracts showed best results against both gram-positive and gram-Negative bacteria.[38] The extraction method and the types of solvents used accounts for the antimicrobial activity.

Anticancer Activity of Microalgal lipids

The human melanocyte A2058 cancer cell line was used to test the anticancer properties of microalgal oil. In micro titer plates with 96 wells, the cells were grown. The results indicated that a considerable survival rate was produced by *S. marinoi* (FE60/2), *A. minutum* (FE126/1), *A. tamutum* (FE107/1 and FE107/3) and *A. andersoni* (FE108/1). The *S. marinoi* clones FE6 and FE60 were also subjected to the anticancer assay; these strains are known to generate hydroxides, oxoacids, hydrogen peroxide, and other components through the breakdown of saturated fatty acids, including polyunsaturated aldehydes. Polyunsaturated aldehyde from FE6 is said to exhibit antiproliferative property on colon carcinoma cells. Additionally, F3E6 did not show any effect on human melanocytes (A2058). According to this assay, anticancer activity of microalgal lipids seems to be cell line-specific. [33]

Anti-Inflammatory Activity of Microalgal Lipids

Microalgal anti-inflammatory potential was evaluated using human acute monocytic leukaemia cell line (THP-1) and ELISA, by observing the release of tumour necrosis factor α (TNF α). Additionally, they noticed that three diatoms, FE2/1, FE326/1, and FE1098_1/1, were only active when cultivated in regular media and inactive when grown in nutrient-deficient conditions. This points out that during adverse conditions, like nutritional scarcity, these species will not generate peptides or chemicals responsible for these actions, or they may produce this at minimal levels. Among which, *C. Closterium* has previously been confirmed that it has anti-inflammatory and antioxidant activities (determined exclusively by enzymatic assay, without utilising cells). [33]

Cytotoxic Activity of Microalgal Lipids

The cytotoxicity was tested after 24 and 72 hours of exposure using human hepatocellular liver cancer (HepG2, ATCC HB-8065TM) and normal human lung fibroblast (MRC-5, ATCC CCL-171TM) cells, respectively. Hepatocytes are great models for studying toxicity because they are the primary location of drug metabolism and biotransformation, which occurs in the liver. To compare normal and cancer cells (A2058) utilised for the anticancer assay, they also incorporated a toxicity test on normal lung fibroblast (MRC-5) cells. The MRC-5 cytotoxicity test was assessed following a 72-hour incubation period for extracts. *O. ovata* extracts (FE119/1, FE119/2, and FE119/3, respectively; Control, Negative, and Positive-starved extracts) likewise caused harm to MRC-5 cells.





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Antioxidant Activity of Microalgal Lipids (CLPAA and CAA)

The extracts were assessed for their overall antioxidant activity and their ability to reduce lipid peroxidation using two antioxidant cellular-based assays, CAA and CLPAA. Antioxidant properties were demonstrated in both tests by growing *O. ovata* in Control, negative and positive-starved media (FE119/1, FE119/2, and FE119/3, respectively). In the CAA assay, FE119/1 showed 66% inhibition of oxidative degeneration and 74% inhibition in the CLPAA assay; in the CAA and CLPAA assays, FE119/2 showed 70% inhibition and 61% inhibition, respectively; in both assays, FE119/3 indicated 69% inhibition. [33]

Antibiofilm activity of Microalgal Lipids

The biofilm-forming bacterium *S. epidermidis* was cultured with extracts at a concentration of 50 g per millilitre in 96 well plates with transparent bottoms for an entire night at 37 °C. The culture mix was supplemented with a concentration of 1 percent glucose to promote the growth of biofilms. It has been discovered that microalgae have anti-biofilm activity, which is an activity directed against the biofilm-forming bacteria *S. epidermidis*. Of the 32 species tested, the two species *L. danicus*(FE322) and *L. aporus* (FE332), which belong to the same microalgal genus, exhibited significant anti-biofilm activity. The development of biofilms, multicellular aggregations with inherent antibiotic resistance, and specific antibiotic resistance genes complicate treatment. Microalgae have been found to have anti-biofilm activity against these bacteria, opening new therapeutic options for *S. epidermidis* infections. Metabolic flexibility has a beneficial impact on developing drugs via the biological activity possibly leading to the discovery of novel compounds that are bioactive for the treatment of human illnesses. [33]

Anti-Diabetic Assay of Microalgal Lipids

Three sets of the experiment were carried out using recombinant human PTP1B and the fluorogenic substrate 6, 8-difluoro-4-methylumbelliferyl phosphate. A type 2 diabetes-related enzyme is called protein tyrosine phosphatase, or PTP1B. To stop insulin from functioning as it should, PTP1B dephosphorylates the insulin receptor and its substrates. Testing for PTP1B activity inhibition using microalgae revealed no appreciable bioactivity. [33]

CONCLUSION

The presence of antioxidants in microalgal lipids is essential for shielding the lipids from oxidative damage, or else result in lipid peroxidation and the production of toxic chemicals. Antioxidants are necessary to keep microalgal lipid-based products stable, exceptional, and long-lasting. Microalgae potentially possess these antioxidants, or else they could be artificially added from external sources during processing. These can be further utilized for various applications.

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Table 1: Lipid Content of Various Microalgae

S. No	Species	Total Lipid Content (% of DW)	Neutral Lipid Content (% of Total Lipid)
1	<i>Nannochloropsis sp.</i>	37–60	23–58
2	<i>Isochrysis sp.</i>	25–33	80
3	<i>Dunaliella salina</i>	23	30
4	<i>Haematococcus pluvialis</i>	16–35	50–59
5	<i>Neochloris oleoabundans</i>	2–47	23–73
6	<i>Phaeodactylum tricorutum</i>	20–30	-
7	<i>Cryptocodinium cohnii</i>	20	-
8	<i>Spirulina platensis</i>	7.6–8.2	-
9	<i>Tetraselmis maculata</i>	8	-
10	<i>Scenedesmus obliquus</i>	12–14	-

Reference: Production of lipids from *Nannochloropsis sp.* [20]





Impact of Microbial Dysbiosis in the Development of Neurodegenerative Disorders

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ABSTRACT

Microbes are ubiquitous, irrespective of the location. Humans and microbes have co-evolved in nature over a million years, inhabiting every part of the human body in a symbiotic relationship. They contribute to vital functions of the body including digestion, nutrition, absorption, immune system, in sickness and health, maintaining a dynamic balance. Various factors influence the human microbiome, food and nutrition, lifestyle, age, genetics, antibiotics taken and underlying diseases. These internal and external factors cause an imbalance in the human microbiota. This imbalance in the microbiota is the cause of many systemic, immunological, and neurological-related diseases. Recent research has highlighted the role of the oral gut-brain axis in neurodegeneration, with growing evidence suggesting that oral and gut dysbiosis play a crucial role in disease pathogenesis and in neurological diseases. In this review, we discussed the role of oral and gut dysbiosis in the development of neurodegenerative diseases with help of oral-gut-brain axis. The review also emphasizes the link between the oral, gut and the brain via the bidirectional connection system between the 'Oral – Gut', 'Gut - Brain' and 'Oral-Gut-Brain' axis. This helps in better understanding of brain system with the gut-brain axis in developing therapeutic techniques for treating neurodegenerative diseases.

Keywords: Oral/gut microbiota, Microbial dysbiosis, Neurodegenerative disorders, Cognition



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INTRODUCTION

Every human being is a harbor for more than 100 million microbes. It is estimated that a number of microbes may be high in number various human cells which includes majorly bacterial species. Other than bacteria, presence of fungi, viruses and other parasites results in the formation of human microbiomes (HM). This HM has a unique network of microflora involved in the maintenance of host homeostasis mechanism and progression of diseases during pathogenic colonization. These microbes are inhabitants in every part of the body like skin, mouth, gut, respiratory tract, etc (Dekaboruah et al. 2020; Hou et al. 2022). However, these residential microbial communities increase in number throughout the growth of the host and decrease with age over 70 years. They can be categorized as pathogenic and non-pathogenic, where the non-pathogenic microbes are found to be more in number than the former. They co-exist together and exhibit symbiotic relationships in a healthy individual. They play a vital role in systemic functions, thereby maintaining human health (Rinninella et al. 2019; Berg et al. 2020). However an imbalance in these microbial communities can lead to various diseases affecting gut health, immune functions, nervous-related disorders etc. The gut and oral microflora are known to be the two largest two microbial communities and play a major role in health sustenance (Uddin et al. 2021; Hou et al. 2022). Disturbance in the microbiota causes many diseases like systemic diseases, infections, cardiovascular diseases, cancer, respiratory diseases, periodontitis, irritable bowel disorders IBDs, neurodegenerative diseases, mental or psychological diseases, liver diseases, and autoimmune diseases (El-Sayed et al. 2021; Gebrayel et al. 2022; Mukilan et al. 2024). Recently, the effect of microbial dysbiosis on neurodegeneration has gained more interest than other systemic diseases. This helps in developing curative methods for neurodegenerative diseases. Recent studies have shown that dysbiosis of oral and gut microbiota not only causes systemic diseases but is also known to affect brain physiology, which contributes majorly to the development of neurodegeneration (Singh et al. 2022; Intili et al. 2023; Mukilan 2023).

ROLE OF ORAL AND GUT MICROFLORA IN HUMAN HEALTH

A person's DNA determines the microbiome network in them. The microbiome houses in the host in the tissues of the placenta, umbilical cord and the amniotic fluid during a healthy pregnancy and shortly after birth through breast feeding, etc., and as the host grows, the microbiome adjusts to the surrounding niche and is diversified into a large adult microbiome in almost every part of the body (Aagaard et al. 2014; Mesa et al. 2020). Also, the microbiome of a baby depends on the mother who is exposed to various environments. This microbiota localizes various regions in the body – skin, eye, nose, gut, respiratory tract, urinary tract, genitals, etc., in which 70% of human health is maintained by oral and gut microbiota. This microbiome exists in symbiosis with the host, benefitting both in their localized region in maintaining homeostasis until the individual is in a healthy state (Hurley et al. 2019; Coscia et al. 2021; Sasso et al. 2023). The microbiota plays a vital role in physiological, metabolic and immunological functions like immune regulation, digestion, absorption of nutrients, production of vitamins, and involved in certain biochemical pathways. Their growth depends on physiological characteristics like temperature, nutrition, lifestyle, etc (Altves et al. 2019; Mukilan 2022; Naliyadhara et al. 2023).

In normal conditions, the concentration of the microflora varies differently among different individuals and also varies from site to site in the same individual. The oral cavity is the second most significant one after the gut in maintaining health. The oral cavity of the baby during birth is usually sterile but the microbes start inhabiting during breastfeeding and followed by the exposure to the external environment. The habitats of the oral cavity can be teeth, buccal mucosa, soft and hard palate and saliva (Deo and Deshmukh 2019; Aggarwal et al. 2022). This harbors not only bacteria but also fungi, viruses and yeasts, by providing a nutrient-rich environment for them. It is also reported that the diet of an individual alters their oral microbiota. Thus, the oral microbiota can influence the body health of an individual. The oral microbiome is usually in the form of a biofilm. It helps in maintaining oral hygiene, and prevents the development of dental caries (Jia et al. 2018; Gschwind et al. 2020; Panzer et al. 2023). Like oral microbiota, gut microbiome being the most significant and the most abundant contains millions of microbes like bacteria, fungi, viruses and protozoa, of which 30% of the microbial population is bacteria. Inhabitation of microbes in the gut begins at birth and is influenced by various factors including breast feeding, introduction of solid foods,





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and dietary changes over the years of host growth. Both external and internal factors contribute to the colonization of the gut microbiota (Gschwind et al. 2020; Panzer et al. 2023). The external factors include breast milk, food taken, etc. and internal factors include the pH of the stomach, intestinal secretions like bile juice, immune responses, antibiotics, etc. The gut bacteria feed and flourish by the diet pattern of the host. The gut bacteria produce vitamins, essential and non-essential amino acids, etc. The gut microbiota influences the overall human health right from birth to the entire lifetime by colonization, metabolizing dietary and pharmaceutical molecules, conferring resistance to pathogens, maintenance of intestinal epithelium, central nervous system, behavior via the gut-brain axis (Agaard et al. 2014; Gschwind et al. 2020; Panzer et al. 2023).

IMPACT OF ORAL AND GUT DYSBIOSIS IN THE DISRUPTION OF HOMEOSTASIS MECHANISM

Besides the physiological distance between the oral cavity and gut, they exhibit a close relation, as the digestive system of the human body begins with the oral cavity and passes through the gut to the anal end. Since gastrointestinal tract GIT and oral cavity are one continuous system, oral health is directly related to gut health. Though both axes have a unique network of microbiomes, overlapping of microbiota between the oral cavity and gut was observed as per the study (Maki et al. 2021). It is found that oral bacteria colonize the gut and activate the immune system in the gut. Oral bacteria can be transferred from the oral to the gut via swallowing, translocation or aspiration. *Bifidobacterium*, a gut bacterium was observed in the oral fluids of neonates babies. Similarly, oral bacterium like *fusobacterium* was observed in the gut in elderly adults (Makino 2018; Toda et al. 2019). Studies like these show that there is an interconnection between oral and gut in regulating the structural, functional and pathophysiological processes. This transmission between oral-to-gut and gut-to-oral is termed the “Oral – Gut Microbiome axis”. The close association between oral and gut is still not clearly understood. But the oral – gut axis helps in studying the pathogenesis and prognosis of the system (Park et al. 2019). Human microbiota affects host physiology to a greater extent at a whole-body level during diseased conditions. A beneficial relationship exists between the host and the microbes as long as the individual is in a healthy state. Dysbiosis means disruption or imbalance in the microbial population (Elzayat et al. 2023). Infection is another common cause of microbial dysbiosis. Dysbiosis causes the host to be more susceptible to infections and diseases. It is determined by various factors like age, food and nutrition, lifestyle changes, hormonal changes, underlying diseases, ecological factors, antibiotics and inherited genes (Wang et al. 2017). These factors alter the normal microbiota causing an imbalance in the microbial population, leading to various diseases including infections, cardiovascular diseases, cancer, respiratory diseases, periodontitis, IBDs, neurodegenerative diseases, mental or psychological diseases, liver diseases, and autoimmune diseases. A large number of studies have shown interlink between diseases/infections and its associated dysbiosis state (Wang et al. 2017; Gebrayel et al. 2022).

In a healthy state, the oral microbes participate in the maintenance of the body's immune system and maintaining homeostasis by resisting other external hindrances. But, when it is encountered by any disturbances above the regulatory level, it is dysregulated, thereby, affecting the oral as well as the overall body health. It is reported to cause diseases like periodontitis, digestive tract diseases, dental caries, glossitis, gingivitis, oral cancer, diabetes and so on (Lamont et al. 2018; Park et al. 2021; Maier 2023). Similarly in the case of gut microbiota, when the host immunity is reduced or affected by some external stress or factors, the micro ecological balance is disturbed. It leads to many diseases like metabolic disorders like obesity, and diabetes, cardiovascular diseases like atherosclerosis (Wang et al. 2017), liver diseases, autoimmune diseases like asthma and arthritis, (IBDs), and it can cause cancer like colorectal cancer, psychological diseases like depression, sleep issues, anxiety, autism, and alzheimer's disease (Treisman 2017). These gut microbiota produce certain chemicals (neurotransmitter precursor compounds) that send signals to the brain affecting the brain health and hence affecting the mental health. The oral bacteria are located closer to the brain and can affect the brain faster than the gut microbiota (O'Mahony et al. 2015; Liu et al. 2024). A bidirectional displacement exists between oral and gut, where oral-to-gut and gut-to-oral transmissions affect or modulate the ecosystem within these two habitats. For example, a decrease in the secretion of gastric juice favors the transmission of oral bacteria to the gut. This leads to dysbiosis and disrupts the regulation of bile juice (Hajishengallis 2016; Park et al. 2021). Gut dysbiosis mostly occurs as a result of antibiotics, which are supposed to target a single



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pathogen but cause the eradication of both 'good' and 'bad' bacteria. Damage of the oral–gut barrier, favors the translocation of bacteria and communication between organs, causing systemic diseases. Gut bacteria may directly or indirectly affects the host immune system and vice versa through oral microorganisms. Recent studies have shown that dysbiosis of oral and gut microbiota not only causes systemic diseases but is also known to affect brain physiology and pathology, which contributes to the development of neurodegeneration (Liu et al. 2022; Intili et al. 2023).

EFFECT OF ORAL AND GUT DYSBIOSIS IN NEURODEGENERATION

Neurodegenerative diseases are caused when the nerve cells of the brain are damaged or lose their functions. The most common neurodegenerative diseases are parkinson's disease, alzheimer's disease, huntington's disease, amyotrophic lateral sclerosis (ALS), and motor neuron disease. Besides the genetic and environmental factors associated with neurodegeneration, the human microbiome plays a major role in neurodegeneration. They cause neurological diseases via various mechanisms mainly involving the bidirectional interaction of oral–to–gut and gut–to–brain axis. Microbiota products impact the brain either directly by producing neurotransmitters or indirectly by stimulating the immune system or by affecting the gastrointestinal tract, autonomic nervous system, or intestinal nervous system (Treisman 2017; Altves et al. 2020). Quite a large number of studies show that oral and gut microbiota play a major part in the development of neurodegenerative diseases. The oral microbiota exhibits a pathway called the 'Oral – gut – brain' axis. The oral bacteria reaches the brain and damages the central nervous system causing neuronal damage through bloodstream via root canal/via gingiva crevices to the capillaries in the gingiva connective tissues, and alveolar blood vessels. The bacteria can also enter the brain via the trigeminal nerve (Teixeira et al. 2017; Zhang et al. 2023). It has been established that oral dysbiosis causing periodontitis may have a connection with neurodegenerative diseases like alzheimer's disease. Disturbances in the oral microbiota cause dysbiosis of the bacterial biofilms in the mouth damaging the structure of the teeth, leading to periodontitis. It was found that *Porphyromonas. gingivalis*, an oral resident bacteria, is the main pathogen causing periodontitis (Franciotti et al. 2021; Wan and Fan, 2023). These pathogens upon oral dysbiosis release pro-inflammatory cytokines like interleukin – 1 IL-1, IL-6 and Tumor necrosis factor TNF- α , which causes plaque formation in the mouth, which further reaches the central nervous system of the brain via hematoencephalic barrier-free areas and fenestrated capillaries or increases the permeability of the brain parenchyma. The brain has a barrier called blood brain barrier (BBB) that prevents the toxic substances from entering the brain (Al-Obaidi et al. 2018; Lei et al. 2023). This pathogen breaks or increases the permeability of the brain causing damage in the transmission of neural signals, by inhibiting the local interferon - γ IFN- γ response and thereby, suppressing the host immune response. A study conducted by Ide et al. 2016, found that increased levels of these cytokines were present in the patients affected with alzheimer's disease.

At baseline, periodontitis showed increase in the cytokine levels. Hence, concluding that periodontitis is associated with the increase in cognitive decline in patients with alzheimer's disease. Later on, another study was conducted on mice model indicated that *P. gingivalis* liposaccharide (LPS) indicated that it affects microglia which induces neuroinflammation and cognitive impairment via the TLR4/NF- κ B signaling pathway, an important characterization of alzheimer's disease. (Zhang et al. 2018). Though studies and evidence show an association between periodontitis and AD, the clear mechanism is still unknown. Some studies showed the deposition of amyloid β plaques and tau protein produced by gut bacterial families *Akkermansiaceae* and *Prevotellaceae*, in the brain in patients with alzheimer's disease. A comprehensive connection between these articles shows there is a connection between dysbiosis of oral microbiota and neurodegenerative diseases. This invasion can be direct or indirect leading to cognitive impairment, a serious consequence of neurodegeneration. But there is no clear idea whether dysbiosis of oral microbiota causes neurodegenerative diseases through periodontitis? Studies also show that dysbiotic imbalance of oral microbiota can also cause other neurodegenerative diseases like Parkinson's disease (Rozas et al. 2021). As equal to the oral microbiota, gut microbiota plays a major role in brain health and physiology via the bidirectional pathway between the gut to brain. These gut microbiota impacts cognitive behavior, depression, neurological diseases like alzheimer's disease, parkinson's disease, ALS, stress, aging, etc. (Zhu et al. 2021). The signaling pathway is complex involving the physiological, metabolic, immunological central nervous system (CNS), autonomic nervous system (ANS), enteric



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neural system (ENS) of the brain and neuronal pathways (Hou et al. 2022). However, the exact relationship between the gut microbiota and neurodegenerative diseases remains unclear. ANS controls the gut functions and triggers the neurological responses of the gut, whereas, the CNS controls the visceral information processing. Other than CNS, ANS also controls the gut microbiota (Wang et al. 2017). The three main signaling pathways include a) the gut-brain axis, where the microbial metabolite reaches the brain via the vagus nerve inducing neurodegeneration, b) the endotoxins pathway, where the accumulation of A β and tau proteins induces the neurocytotoxic mechanisms and c) the mitochondrial pathway, where the intestinal metabolite short-chain fatty acids SCFAs induces neuro cytotoxic mechanism (Loh et al. 2024). The gut microbiota affects the nervous system of the brain via neurotransmitters like catecholamines, tryptophan, serotonin, etc. These signals directly activate the vagus nerve that connects the gut and the brain and in addition to this, alterations in (SCFA), an important metabolic product of the gut, are shown to be associated with neurodegeneration (Bruning et al. 2020; Hou et al. 2022). Besides, the impact of gut microbiota on other systemic diseases, its role in neurodegenerative diseases has become an important area of research. *Bacillus subtilis* and *Escherichia coli* are very common residents of intestinal microbiota and present in steady balance when the host is in a healthy state. However, these organisms are affected by external factors like pathogens and result in the dysbiosis of residential flora. These *B. subtilis* and *E. coli* secrete lipopolysaccharides (LPS) and amyloid proteins in large amounts. These pro-inflammatory proteins directly pass through the blood-brain barrier (BBB) from the gut by decreasing the intestinal permeability and accumulate in the brain, inducing synaptic toxicity and neuronal death or directly pass through the physiological barrier, provoking the degeneration of the nervous system, leading to the development of neurodegenerative diseases like alzheimer's disease (Jiang et al. 2017; Intili et al. 2023).

CONCLUSION

Recent studies have shown that in healthy conditions, every human body consists of a unique network of microbes like bacteria, viruses, fungi, protozoan and archaea, making up the site-specific human microbiome. This site-specific human microbiome is involved in the regulation of host homeostasis mechanisms like digestion, cognition, and systemic regulation. However, these regulated functions work in a dynamic balance until the body is affected or disturbed by any internal or external stresses. Other than external stresses, internal stress like oral/gut dysbiosis of microbiota may lead to several disorders like physiological, systemic, immunological, and neurological diseases. Among these types of disorders, neurological diseases like alzheimer's disease, parkinson's disease, and mild cognitive impairment were progressed by infection with periodontal and non-periodontal pathogens at a higher level. The progression of these disorders results in the development of dysbiosed state of microorganisms in the oral cavity and the gut. Colonization of pathogens in the oral cavity/gut may indirectly trigger the inflammatory response in the CNS via transmission of virulence factors, and metabolites through the blood-brain barrier. Thus the present review opened up the role of virulence factors in the development of brain neuroinflammation in neurodegenerative disorders. Future research studies will prove the role of specific virulence factors of periodontal and non-periodontal pathogens in the development of neuroinflammation in different brain regions.

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Table 1. Residential microflora and their localized regions

Regions	Microflora	Genus	References
Placenta	Bacteria	Actinobacterium Fusobacteria Firmicutes Bacteroidetes Proteobacteria	Agaard et al. 2014; Gschwind et al. 2020; Panzer et al. 2023
Umbilical cord	Bacteria	Streptococcus Enterococcus Staphylococcus	Agaard et al. 2014; Gschwind et al. 2020; Hemberg et al. 2023
Breast milk	Bacteria	Lactobacillus Bifidobacterium	Altves et al. 2019; Notarbartolo et al. 2022; Wang et al. 2023
Skin	Bacteria	Actinobacteria Bacteroidetes Cyanobacteria Firmicutes Proteobacteria Staphylococcus	Skowron et al. 2021; Hou et al. 2022; Skaar 2023
	Fungi	Candida Pneumocystis	Leung et al. 2016; Rokas 2022





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Nail flora	Fungi	Aspergillus Penicillium Cladosporium	Belizario et al. 2021
Oral Cavity	Bacteria	Actinobacteria Fusobacteria Bacteroidetes Firmicutes Proteobacteria	Caselli et al. 2020; Hou et al. 2022; Chopra et al. 2024
Gut	Bacteria	Actinobacteria Bacteroidetes Firmicutes Lactobacillae Streptococci Enterobacteria Prevotella Ruminococcus	Agaard et al. 2014; Gschwind et al. 2020; Panzer et al. 2023
	Fungi	Candida Saccharomyces Malassezia Cladosporium	Auchtung et al. 2018; Zhang et al. 2022
Colon	Bacteria	Bifidobacterium Clostridium Lactobacillus Peptostreptococcus	Gschwind et al. 2020; Panzer et al. 2023
Respiratory tract	Bacteria	Actinobacteria Bacteroidetes Firmicutes Proteobacteria Veilonella Moraxella	Agaard et al. 2014; Gschwind et al. 2020; Panzer et al. 2023
	Fungi	Candida	Zhang et al. 2022

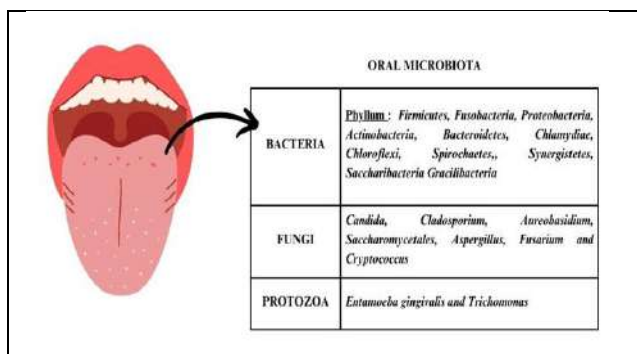


Figure 1. Pictorial representation showing the presence of various microorganisms like bacteria, fungi, and protozoa in the oral cavity.

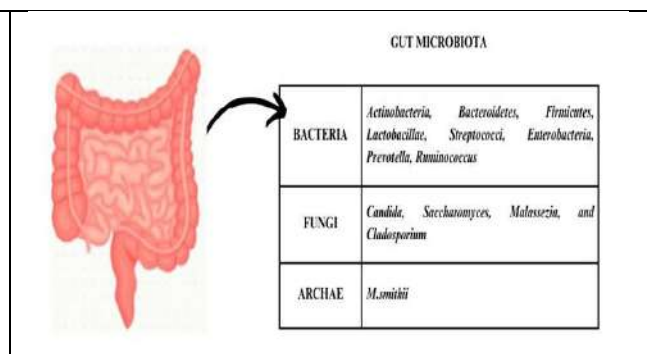


Figure 2. Pictorial representation showing the presence of microorganisms like bacteria, fungi, and archaea in the gut.





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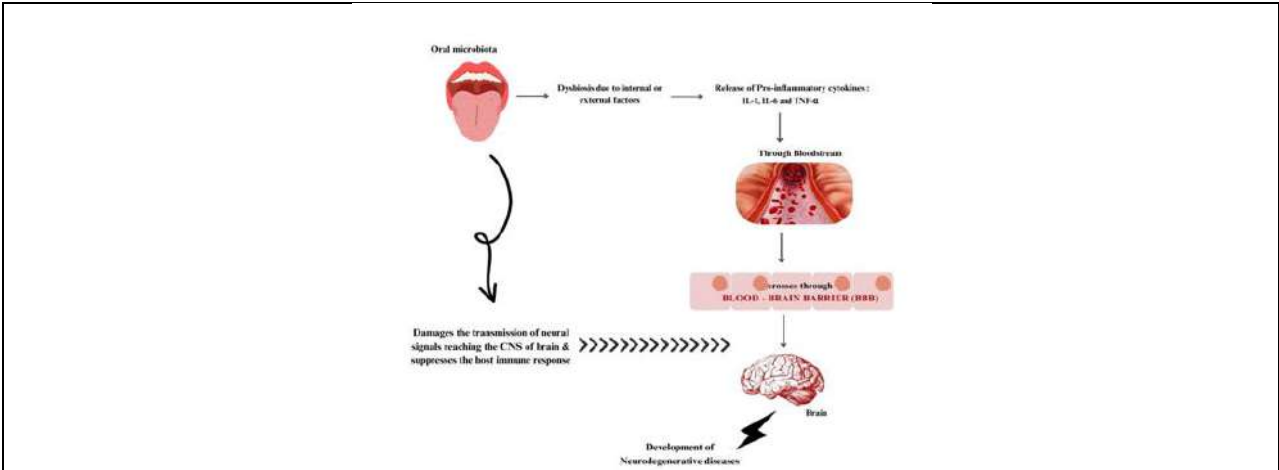


Figure 3. Flow diagram showing the role of dysbiosed oral microbiota in the development of neurodegenerative disorders.





Semi-Analytical Study on A Finite Boundary Value Problem for Magnetohydrodynamic Fluid Flow

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ABSTRACT

In this work, we have to explore the semi-analytical solution for the steady flow of thermal analysis of MHD Williamson fluid flows through a micro channel. Here, the dimensionless predominant equations are solved with the help of the Homotopy analysis method (HAM). The semi-analytical expressions for non-dimensional velocity and non-dimensional temperature are presented. The results have good accuracy as compared to the numerical solution. Also, the effect of Biot number on the substantial fluid temperature is demonstrated graphically. Bejan number and entropy generation numbers are derived and displayed graphically. This approach may also be extended to solve other non-linear problems.

Keywords: Micro channel, Entropy generation, Convective boundary conditions, Homotopy analysis method, Williamson fluid.

INTRODUCTION

Agboola et al. [19] analysed the natural convection flow of the vertical micro channel via the difference transform method. The transformed equations of velocity and temperature profiles were investigated and they reported that both hall current and wall ambient temperature were irreversible. Ananthaswamy et al. [17] investigated the Navier-Stokes equations for a steady magnetohydrodynamic (MHD) flow between two parallel porous plates and the non-linear differential equation was solved using the q-Homotopy analysis method to influence the flow parameters. Khan et al. [21] exclaimed about the steady magnetized two dimensional incompressible flow of Jeffrey nanofluid that developed over a stretched, curved surface with combined characteristics of activation energy.





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Modern developments in the field of fluid dynamics on nanofluids including maintaining remarkable thermal conductivity properties using the Runge-Kutta (RK) - method by Khan et al. [5, 6], (2019). Madhu et al. [1, 12] studied the Eyring-powell fluid through an inclined micro channel in the presence of radiation and convection heating effects and analyzed the entropy generation of the system in non-dimensional form. The set of converted equations can be solved by the finite element method. Makinde et al. [11] investigated the influence of thermal radiation, magnetic field, wall suction, and porous medium on the forced MHD flow of electrically conducting casson fluid in a horizontal micro channel with boundary slip and saturated with porous medium. Malik et al. [8] explained that when heat generation and absorption effects are taken into account, the corresponding PDEs are converted into ODEs and resolved by the RK Fehlberg method. Nadeem et al. [9] explained the two dimensional Williamson fluid flow model by using similarity transformations and the equations were analytically resolved by HAM. Ogunseye et al. [10] discussed the heat transfer performance and entropy generation rate in a mixed convection flow of a hydromagnetic aluminium oxide-water powell-eyring nanofluid flow through a vertical channel. The result of this study may help engineers optimize thermal systems. Qayyum et al. [6] presented the numerical analysis of MHD flow through a porous medium bounded by a non-linearly stretching flat surface. The graphical presentation of results highlights that the heat flux receives enhancement for augmented Brownian diffusion. Rana et al. [2] explained that the flow and heat transfer of a nanofluid over a stretching sheet with Brownian motion, thermophoresis effects. Reddy [3] introduced the finite element approach, which is applied in different fields. An extreme compact flow heat exchanger was described and constructed with the furnace brazing of stainless steel sheets. The argument, which is based on calculations, depends upon exchanger geometry and fluid pressure, as explained by Swift et al. [20]. Waqas et al. [4] described how the detailed analytical outcomes are compared with the numerical parameters. In this current study, we have discussed the semi-analytical solution for the steady flow of thermal analysis of MHD Williamson fluid flows through a micro channel. The corresponding PDEs are converted to ODEs using the similarity transformation. The dimensionless velocity and dimensionless temperature equations are solved using HAM. The results are then compared with numerical solutions. Several physical characteristics involved in this issue are graphically displayed to show the convergence of this method.

Mathematical formulation of the problem

Here we seen the steady fully developed incompressible dissipative flow of a Williamson fluid over a micro channel bounded by parallel two horizontal plates separated by width. The infinite lower plate of the micro channel is also placed by $y=0$, while above the lower plate is at $y=h$. Flow is along the y -axis and the physical quantity depends only on transversal coordinate y while magnetic effects of uniform strength B_0 are discussed transversely to the plate.

The flow is shown in the Fig. 1.

$$\rho v_0 \frac{du}{dy} = -\frac{dp}{dx} + \mu \left(1 + \sqrt{2} \Gamma \frac{du}{dy} \right) \frac{d^2 u}{dy^2} - \sigma B_0^2 u \quad (1)$$

$$\rho C_p v_0 \frac{dv}{dy} = -k \frac{d^2 T}{dy^2} + \mu \left(1 + \frac{\Gamma}{\sqrt{2}} \frac{du}{dy} \right) \left(\frac{du}{dy} \right)^2 + \sigma B_0^2 u^2 \quad (2)$$

Under the following boundary- conditions we get:

$$\begin{aligned} u = 0, \quad k \frac{dT}{dy} - h_1(T - T_2) = 0, \quad \text{at } y = 0, \\ u = 0, \quad k \frac{dT}{dy} + h_2(T - T_1) = 0, \quad \text{at } y = h, \end{aligned} \quad (3)$$

The eqns. (1) – (3) are non-dimensionalised using the below relationships

$$u = \frac{\mu}{\rho h} f(\eta), \quad \eta = \frac{y}{h}, \quad \theta = \frac{T - T_1}{T - T_2} \quad (4)$$





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Using above relationships; the eqns. (1) - (3) can be expressed as

$$(1 + W_e f') f''' - \text{Re} f' - M^2 f + P = 0 \tag{5}$$

$$\theta'' - \text{Re Pr} \theta' + Ec \text{Pr} \left[\left(1 + \frac{W_e}{2} f' \right) (f')^2 + M^2 f^2 \right] = 0 \tag{6}$$

Dimensionless forms of boundary conditions are:

$$\begin{aligned} f = 0, \quad \theta' - Bi_1(\theta - 1) = 0, \quad \text{at} \quad \eta = 0 \\ f = 0, \quad \theta' + Bi_2(\theta) = 0 \quad \text{at} \quad \eta = 1 \end{aligned} \tag{7}$$

Where, $P = \frac{\rho h^3}{\mu^2} \left(-\frac{dp}{dx} \right)$ pressure gradient parameter, $W_e = \frac{\sqrt{2}\mu\Gamma}{\rho h^2}$ is weissenberg number

$\text{Re} = \frac{\rho g_0 h}{\mu}$ Reynolds number, $M = \sqrt{\frac{\sigma B_0^2 h^2}{\mu}}$ is Magnetic parameter, $\text{Pr} = \frac{\rho C_p}{k}$ prandtl number,

$Ec = \frac{\mu^2}{h^2 \rho^2} \frac{1}{C_p (T_2 - T_1)}$ Eckert number, and $Bi = \frac{-hh_i}{k}$ for $i = 1, 2$, is Biot number.

Entropy generation

The obtained temperature and velocity fields are used to determine the irreversibility rate within the micro channel. Under convective peripheral condition for the Williamson fluid model the aspects influencing the entropy are fluid friction, heat transfer and magnetic field and are defined below,

$$E_g = \frac{k}{T_1^2} \left(\frac{dT}{dy} \right)^2 + \frac{1}{T_1} \left[\mu \left(1 + \frac{\Gamma}{\sqrt{2}} \frac{du}{dy} \right) \right] \left(\frac{du}{dy} \right)^2 + \sigma B_0^2 u^2 \tag{8}$$

By using relation eqn. (4) non- dimension form of eqn. (8) is

$$N_s = \frac{E_g}{E_0} = (\theta')^2 + Ec \text{Pr} L \left[\left(1 + \frac{W_e}{2} f' \right) (f')^2 + M^2 f^2 \right] \tag{9}$$

where, $E_0 = \frac{k(T_2 - T_1)^2}{h^2 T_1^2}$ denoted the characteristic entropy generation rate, $L = \frac{T_1}{T_2 - T_1}$ represents

characteristic temperature ratio.

Hence alternative form of eqn. (9) can be expressed as below:

$$N_s = N_h + N_v \tag{10}$$

The Bejan number (Be) is the ratio generation of entropy due to heat transfer irreversibility (N_h) to the generation of entropy due to heat transfer irreversibility and viscous dissipation ($N_h + N_v$) is defined as follows,

$$Be = \frac{N_h}{N_h + N_v} \tag{11}$$

Semi-analytical expression of the dimensionless velocity, temperature with the help of the HAM [13-18]

Several issues in physical, chemical and engineering sciences can be solved by the Homotopy analysis method. It is non-perturbative. It offers a series solution for non-linear equations. The non-linearity in a non- linear differential





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equation is a polynomial that contains the unknown function and its derivatives specified in previous studies. An innovative analytical method namely “Homotopy analysis method” was introduced by Liao [13-16]. This provides possible ways to estimate the solution and from the infinite power series. A finite number of terms and the system of differential equations were solved and which examined the accuracy of this method (HAM). In this technique, there is an auxiliary parameter h that helps us to control and modify the convergence region of the solution series. Applying HAM to dimensionless velocity and dimensionless temperature profiles, we have derived approximate analytical expressions for the same.

$$\begin{aligned}
 f(\eta) &= a_3 e^{a_2 \eta} + \frac{P(e^{a_2} - 1)e^{a_1 \eta}}{M^2(e^{a_2} - e^{a_1})} - \frac{P}{M^2} \\
 &\quad - h \left(\frac{-W_e a_6 - W_e a_6 e^{a_2}}{e^{a_2} - e^{a_1}} + \left(\frac{a_3^2 a_2^3 e^{\left(\frac{\text{Re} + \sqrt{\text{Re}^2 + 4M^2}}{a_5}\right)}}{W_e + \frac{P^2(e^{a_2} - 1)^2 a_1^3 e^{\left(\frac{\text{Re} - \sqrt{\text{Re}^2 + 4M^2}}{M^4(e^{a_2} - e^{a_1})^2 a_4}\right)}}}{\frac{a_3 P(e^{a_2} - 1) a_2 a_1 \text{Re} e^{\text{Re}}}{M^4(e^{a_2} - e^{a_1})}} \right) e^{a_2 \eta} \right) \\
 &\quad - h \left(\frac{-W_e a_6 e^{a_2} + W_e}{e^{a_2} - e^{a_1}} + \left(\frac{a_3^2 a_2^3 e^{\left(\frac{\text{Re} + \sqrt{\text{Re}^2 + 4M^2}}{a_5}\right)}}{\frac{P^2(e^{a_2} - 1)^2 a_1^3 e^{\left(\frac{\text{Re} - \sqrt{\text{Re}^2 + 4M^2}}{M^4(e^{a_2} - e^{a_1})^2 a_4}\right)}}}{\frac{a_3 P(e^{a_2} - 1) a_2 a_1 \text{Re} e^{\text{Re}}}{M^4(e^{a_2} - e^{a_1})}} \right) e^{a_1 \eta} \right) \\
 &\quad + W_e \left(\frac{a_3^2 a_2^3 e^{\left(\frac{\text{Re} + \sqrt{\text{Re}^2 + 4M^2}}{a_5}\right)}}{\frac{P^2(e^{a_2} - 1)^2 a_1^3 e^{\left(\frac{\text{Re} - \sqrt{\text{Re}^2 + 4M^2}}{M^4(e^{a_2} - e^{a_1})^2 a_4}\right)}}}{\frac{a_3 P(e^{a_2} - 1) a_2 a_1 \text{Re} e^{\text{Re}}}{M^4(e^{a_2} - e^{a_1})}}} \right)
 \end{aligned}
 \tag{12}$$





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$$\theta(\eta) = \frac{Bi_1 (Re Pr e^{(Re Pr)} + Bi_2 e^{(Re Pr)}) - Bi_1 Bi_2 e^{(Re Pr)}}{Bi_2 (Re Pr - Bi_1) + Bi_1 (Re Pr e^{(Re Pr)} + Bi_2 e^{(Re Pr)})} - h$$

$$\left(\frac{1}{Bi_2} \left(-Ec Pr a_{15} - Ec Pr a_{14} Bi_2 - (c_{11}) e^{Re Pr} (Re Pr + Bi_2) \right) + (c_{11}) e^{Re Pr \eta} \right)$$

$$\frac{Bi_2 (Re Pr - Bi_1) + Bi_1 e^{Re Pr} (Re Pr + Bi_2)}{a_3^2 a_1^2 e^{2a_1 \eta} + \frac{P^2 (e^{a_1} - 1) a_2^2 e^{2a_2 \eta}}{M^4 (e^{a_1} - e^{a_2})^2 a_9} + \frac{2a_3 P (e^{a_1} - 1) a_1 a_2 e^{Re \eta}}{M^2 (e^{a_1} - e^{a_2}) (Re^2 - Re^2 Pr)}$$

$$+ Ec Pr + \frac{W_e}{2} \left(\frac{P^3 (e^{a_1} - 1)^3 a_2^3 e^{3a_2 \eta}}{M^6 (e^{a_1} - e^{a_2})^3 a_7} + \frac{3a_1^2 a_3^2 P (e^{a_1} - 1) a_2 e^{a_6 \eta}}{M^2 (e^{a_1} - e^{a_2}) (a_6^2 - Re Pr a_6)} \right)$$

$$+ \frac{3a_1 a_3 P^2 (e^{a_1} - 1)^2 a_2^2 e^{Re \eta}}{M^4 (e^{a_1} - e^{a_2})^2 (a_5^2 - Re Pr a_5)} + \frac{a_3^3 a_1^3 e^{3a_1 \eta}}{a_8}$$

$$+ M^2 \left(- \frac{2Pa_3 e^{a_1 \eta}}{M^2 (a_1^2 - a_1 Re Pr)} + \frac{P^2 (e^{a_1} - 1)^2 e^{2a_2 \eta}}{M^4 (e^{a_1} - e^{a_2})^2 (a_2^2 - a_2 Re Pr)} \right)$$

$$- \frac{2P^2 (e^{a_1} - 1) e^{a_2 \eta}}{M^4 (e^{a_1} - e^{a_2}) (a_2^2 - a_2 Re Pr)}$$

$$+ \frac{2a_3 P (e^{a_1} - 1) e^{Re \eta}}{M^2 (e^{a_1} - e^{a_2}) (Re^2 - Re^2 Pr)} + \frac{a_3^2 e^{2a_1 \eta}}{a_4}$$
(13)

Where,

$$A = \frac{P}{M^2} - B, \quad B = \frac{P}{M^2} \left(\frac{e^{a_1} - 1}{e^{a_1} - e^{a_2}} \right), \quad A_{22} = \frac{-c_4 - c_3 B_{i_2} - B_{22} e^{Re Pr} (Re Pr + B_{i_2})}{B_{i_2}}$$

$$B_{22} = \frac{-B_{i_1} B_{i_2} (1 - c_1) - c_2 B_{i_2} - c_4 B_{i_1} - B_{i_1} B_{i_2} c_3}{B_{i_2} (Re Pr - B_{i_1}) + B_{i_1} e^{Re Pr} (Re Pr + B_{i_2})}, \quad c = -a_3 - D_1, \quad D_1 = \frac{a_4 - a_3 e^{a_1}}{e^{a_1} - e^{a_2}}$$

$$A_1 = - \frac{B_1 (Re Pr e^{Re Pr} + B_{i_2} e^{Re Pr})}{B_{i_2}}, \quad B_1 = - \frac{B_{i_1} B_{i_2}}{B_{i_2} (Re Pr - B_{i_1}) + B_{i_1} (Re Pr e^{Re Pr} + B_{i_2} e^{Re Pr})}$$
(14)





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$$c_1 = EcPr \left(\begin{aligned} & \left(\frac{a_3^2 a_1^2}{4a_1^2 - 2a_1 \operatorname{Re} Pr} + \frac{P^2 (e^{a_1} - 1)^2 a_2^2}{M^4 (e^{a_1} - e^{a_2})^2 (4a_2^2 - 2a_2 \operatorname{Re} Pr)} \right. \\ & + \frac{2a_3 P (e^{a_1} - 1) a_1 a_2}{M^2 (e^{a_1} - e^{a_2}) (\operatorname{Re}^2 - \operatorname{Re}^2 Pr)} \\ & + \frac{W_e}{2} \left(\frac{a_3^3 a_1^3}{9a_1^2 - 3a_1 \operatorname{Re} Pr} + \frac{P^3 (e^{a_1} - 1)^3 a_2^3}{M^6 (e^{a_1} - e^{a_2})^3 (9a_1^2 - 3a_2 \operatorname{Re} Pr)} \right. \\ & + \frac{3a_1^2 a_3^2 P (e^{a_1} - 1) a_2}{M^2 (e^{a_1} - e^{a_2}) (a_6^2 - \operatorname{Re} Pr a_6)} \\ & + \frac{3a_1 a_3 P^2 (e^{a_1} - 1)^2 a_2^2}{M^4 (e^{a_1} - e^{a_2})^2 (a_5^2 - \operatorname{Re} Pr a_5)} \\ & + M^2 \left(\frac{P^2 (e^{a_1} - 1)^2}{M^4 (e^{a_1} - e^{a_2})^2 (a_2^2 - a_2 \operatorname{Re} Pr)} \right. \\ & + \frac{2a_3 P (e^{a_1} - 1)}{M^2 (e^{a_1} - e^{a_2}) (\operatorname{Re}^2 - \operatorname{Re}^2 Pr)} + \frac{a_3^2}{4a_1^2 - 2a_1 \operatorname{Re} Pr} \\ & \left. \left. - \frac{2Pa_3}{M^2 (a_1^2 - a_1 \operatorname{Re} Pr)} - \frac{2P^2 (e^{a_1} - 1)}{M^4 (e^{a_1} - e^{a_2}) (a_2^2 - a_2 \operatorname{Re} Pr)} \right) \right) \end{aligned} \right) \tag{15}$$

$$c_2 = EcPr \left(\begin{aligned} & \left(\frac{a_3^2 a_1^2 a_{11}}{4a_1^2 - 2a_1 \operatorname{Re} Pr} + \frac{P^2 (e^{a_1} - 1)^2 a_2^2 a_{10}}{M^4 (e^{a_1} - e^{a_2})^2 (4a_2^2 - 2a_2 \operatorname{Re} Pr)} \right. \\ & + \frac{2a_3 P (e^{a_1} - 1) a_1 a_2 \operatorname{Re}}{M^2 (e^{a_1} - e^{a_2}) (\operatorname{Re}^2 - \operatorname{Re}^2 Pr)} \\ & + \frac{W_e}{2} \left(\frac{a_3^3 a_1^3 a_{13}}{9a_1^2 - 3a_1 \operatorname{Re} Pr} + \frac{P^3 (e^{a_1} - 1)^3 a_2^3 a_{14}}{M^6 (e^{a_1} - e^{a_2})^3 (9a_1^2 - 3a_2 \operatorname{Re} Pr)} \right. \\ & + \frac{3a_1^2 a_3^2 P (e^{a_1} - 1) a_2 a_6}{M^2 (e^{a_1} - e^{a_2}) (a_6^2 - \operatorname{Re} Pr a_6)} \\ & + \frac{3a_1 a_3 P^2 (e^{a_1} - 1)^2 a_2^2 a_5}{M^4 (e^{a_1} - e^{a_2})^2 (a_5^2 - \operatorname{Re} Pr a_5)} \\ & + M^2 \left(\frac{P^2 (e^{a_1} - 1)^2 a_{10}}{M^4 (e^{a_1} - e^{a_2})^2 (a_2^2 - a_2 \operatorname{Re} Pr)} + \frac{2a_3 P (e^{a_1} - 1) \operatorname{Re}}{M^2 (e^{a_1} - e^{a_2}) (\operatorname{Re}^2 - \operatorname{Re}^2 Pr)} \right. \\ & - \frac{2P^2 (e^{a_1} - 1) a_2}{M^4 (e^{a_1} - e^{a_2}) (a_2^2 - a_2 \operatorname{Re} Pr)} + \frac{a_3^2 a_{11}}{4a_1^2 - 2a_1 \operatorname{Re} Pr} \\ & \left. \left. - \frac{2Pa_3 a_1}{M^2 (a_1^2 - a_1 \operatorname{Re} Pr)} \right) \right) \end{aligned} \right) \tag{16}$$





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$$c_3 = EcPr \left(\begin{aligned} & \left(\frac{a_3^2 a_1^2 e^{a_{11}}}{4a_1^2 - 2a_1 Re Pr} + \frac{P^2 (e^{a_1} - 1)^2 a_2^2 e^{a_{10}}}{M^4 (e^{a_1} - e^{a_2})^2 (4a_2^2 - 2a_2 Re Pr)} \right. \\ & + \frac{2a_3 P (e^{a_1} - 1) a_1 a_2 e^{Re}}{M^2 (e^{a_1} - e^{a_2}) (Re^2 - Re^2 Pr)} \\ & + \frac{W_e}{2} \left(\frac{a_3^3 a_1^3 e^{a_{13}}}{9a_1^2 - 3a_1 Re Pr} + \frac{P^3 (e^{a_1} - 1)^3 a_2^3 e^{a_{14}}}{M^6 (e^{a_1} - e^{a_2})^3 (9a_1^2 - 3a_2 Re Pr)} \right. \\ & + \frac{3a_1^2 a_3^2 P (e^{a_1} - 1) a_2 e^{a_6}}{M^2 (e^{a_1} - e^{a_2}) (a_6^2 - Re Pr a_6)} + \frac{3a_1 a_3 P^2 (e^{a_1} - 1)^2 a_2^2 e^{a_5}}{M^4 (e^{a_1} - e^{a_2})^2 (a_5^2 - Re Pr a_5)} \\ & + M^2 \left(\frac{a_3^2 e^{a_{11}}}{4a_1^2 - 2a_1 Re Pr} + \frac{P^2 (e^{a_1} - 1)^2 e^{a_{10}}}{M^4 (e^{a_1} - e^{a_2})^2 (a_2^2 - a_2 Re Pr)} \right. \\ & + \frac{2a_3 P (e^{a_1} - 1) e^{Re}}{M^2 (e^{a_1} - e^{a_2}) (Re^2 - Re^2 Pr)} - \frac{2P^2 (e^{a_1} - 1) e^{a_2}}{M^4 (e^{a_1} - e^{a_2}) (a_2^2 - a_2 Re Pr)} \\ & \left. \left. - \frac{2Pa_3 e^{a_1}}{M^2 (a_1^2 - a_1 Re Pr)} \right) \right) \end{aligned} \right) \quad (17)$$

$$\begin{aligned} a_1 &= \frac{Re}{2} + \frac{1}{2} \sqrt{Re^2 + 4M^2}, & a_2 &= \frac{Re}{2} - \frac{1}{2} \sqrt{Re^2 + 4M^2}, & a_3 &= \frac{P}{M^2} - \frac{P(e^{a_1} - 1)}{M^2 (e^{a_1} - e^{a_2})}, \\ a_4 &= 4a_1^2 - 2a_1 Re Pr, & a_5 &= \frac{3Re}{2} - \frac{1}{2} \sqrt{Re^2 + 4M^2}, & a_6 &= \frac{3Re}{2} + \frac{1}{2} \sqrt{Re^2 + 4M^2} \\ a_7 &= 9a_2^2 - 3a_2 Re Pr, & a_8 &= 9a_1^2 - 3a_1 Re Pr, & a_9 &= 4a_2^2 - 2a_2 Re Pr, \\ a_{10} &= Re - \sqrt{Re^2 + 4M^2}, & a_{11} &= Re + \sqrt{Re^2 + 4M^2}, & a_{12} &= \frac{3Re}{2} - \frac{3}{2} \sqrt{Re^2 + 4M^2} \end{aligned} \quad (18)$$

$$\begin{aligned} a_{13} &= \frac{3R}{2} + \frac{3}{2} \sqrt{R^2 + 4M^2} \\ a_{14} &= \frac{a_3^2 a_1^2 e^{a_{13}}}{a_8} + \frac{P^2 (e^{a_1} - 1) a_2^3 e^{a_{12}}}{M^4 (e^{a_1} - e^{a_2}) a_9} + \frac{2a_3 P (e^{a_1} - 1) a_1 a_2 e^{Re}}{M^2 (e^{a_1} - e^{a_2}) (Re^2 - Re^2 Pr)} \\ & + \frac{W_e}{2} \left(\frac{a_3^3 a_1^3 e^{3a_1}}{a_8} + \frac{P^3 (e^{a_1} - 1)^3 a_2^3 e^{a_{12}}}{M^6 (e^{a_1} - e^{a_2})^3 a_7} + \frac{3a_1^2 a_3^2 P (e^{a_1} - 1) a_2 e^{a_6}}{M^2 (e^{a_1} - e^{a_2}) (a_6^2 - Re Pr a_6)} \right. \\ & \left. + \frac{3a_1 a_3 P^2 (e^{a_1} - 1)^2 a_2^2 e^{a_5}}{M^4 (e^{a_1} - e^{a_2})^2 (a_5^2 - Re Pr a_5)} \right) \\ & + M^2 \left(\frac{a_3^2 e^{a_{11}}}{a_4} + \frac{P^2 (e^{a_1} - 1)^2 e^{a_{10}}}{M^4 (e^{a_1} - e^{a_2})^2 (a_2^2 - a_2 Re Pr)} + \frac{2a_3 P (e^{a_1} - 1) e^{Re}}{M^2 (e^{a_1} - e^{a_2}) (Re^2 - Re^2 Pr)} \right. \\ & \left. - \frac{2P^2 (e^{a_1} - 1) e^{a_2}}{M^4 (e^{a_1} - e^{a_2}) (a_2^2 - a_2 Re Pr)} - \frac{2Pa_3 e^{a_1}}{M^2 (a_1^2 - a_1 Re Pr)} \right) \end{aligned} \quad (19)$$





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$$\begin{aligned}
 a_{15} = & \frac{a_3^2 a_1^2 a_{11} e^{a_{11}}}{a_4} + \frac{P^2 (e^{a_1} - 1)^2 a_2^2 a_{10} e^{a_{10}}}{M^4 (e^{a_1} - e^{a_2})^2 a_9} + \frac{2a_3 P (e^{a_1} - 1) a_1 a_2 \operatorname{Re} e^{\operatorname{Re}}}{M^2 (e^{a_1} - e^{a_2}) (\operatorname{Re}^2 - \operatorname{Re}^2 \operatorname{Pr})} \\
 & + \frac{W_e}{2} \left(\frac{a_3^3 a_1^3 a_{13} e^{a_1}}{a_8} + \frac{P^3 (e^{a_1} - 1)^3 a_2^3 e^{a_{12}}}{M^6 (e^{a_1} - e^{a_2})^3 a_7} + \frac{3a_1^2 a_3^2 P (e^{a_1} - 1) a_2 e^{a_6}}{M^2 (e^{a_1} - e^{a_2}) (a_6^2 - \operatorname{Re} \operatorname{Pr} a_6)} \right. \\
 & \left. + \frac{3a_1 a_3 P^2 (e^{a_1} - 1)^2 a_2^2 e^{a_5}}{M^4 (e^{a_1} - e^{a_2})^2 (a_5^2 - \operatorname{Re} \operatorname{Pr} a_5)} \right) \\
 & + M^2 \left(\frac{P^2 (e^{a_1} - 1)^2 e^{a_{10}}}{M^4 (e^{a_1} - e^{a_2})^2 (a_2^2 - a_2 \operatorname{Re} \operatorname{Pr})} + \frac{2a_3 P (e^{a_1} - 1) e^{\operatorname{Re}}}{M^2 (e^{a_1} - e^{a_2}) (\operatorname{Re}^2 - \operatorname{Re}^2 \operatorname{Pr})} \right. \\
 & \left. - \frac{2P^2 (e^{a_1} - 1) e^{a_2}}{M^4 (e^{a_1} - e^{a_2}) (a_2^2 - a_2 \operatorname{Re} \operatorname{Pr})} - \frac{2Pa_3 e^{a_1}}{M^2 (a_1^2 - a_1 \operatorname{Re} \operatorname{Pr})} + \frac{a_3^2 a_{11} e^{a_{11}}}{a_4} \right) \tag{20}
 \end{aligned}$$

$$N_s = (\theta')^2 + Ec \operatorname{Pr} L \left[\left(1 + \frac{W_e}{2} f' \right) (f')^2 + M^2 f^2 \right] \tag{21}$$

$$B_s = \frac{(\theta')^2}{(\theta')^2 + Ec \operatorname{Pr} L \left[\left(1 + \frac{W_e}{2} f' \right) (f')^2 + M^2 f^2 \right]} \tag{22}$$





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$$\begin{aligned}
 c_{11} = & \left(-Bi_1 Bi_2 \left(1 - Ec Pr \right) \left(\begin{aligned} & \left(\frac{a_3^2 a_1^2}{a_4} + \frac{P^2 (e^{a_1} - 1) a_2^2}{M^4 (e^{a_1} - e^{a_2})^2 a_9} \right. \right. \\ & + \frac{2a_3 P (e^{a_1} - 1) a_1 a_2}{M^2 (e^{a_1} - e^{a_2}) (Re^2 - Re^2 Pr)} \\ & + \frac{1}{2} W_e \left(\begin{aligned} & \left(\frac{a_3^3 a_1^3}{a_8} + \frac{P^3 (e^{a_1} - 1)^3 a_2^3}{M^6 (e^{a_1} - e^{a_2})^3 a_7} \right) + \\ & \frac{3a_1^2 a_3^2 P (e^{a_1} - 1) a_2}{M^2 (e^{a_1} - e^{a_2}) (a_6^2 - Re Pr a_6)} \\ & + \frac{3a_1 a_3 P^2 (e^{a_1} - 1)^2 a_2^2}{M^4 (e^{a_1} - e^{a_2})^2 (a_5^2 - Re Pr a_5)} \end{aligned} \right) \\ & + M^2 \left(\begin{aligned} & \left(\frac{a_3^2}{a_4} + \frac{P^2 (e^{a_1} - 1)^2}{M^4 (e^{a_1} - e^{a_2})^2 (a_2^2 - a_2 Re Pr)} \right) \\ & + \frac{2a_3 P (e^{a_1} - 1)}{M^2 (e^{a_1} - e^{a_2}) (Re^2 - Re^2 Pr)} \\ & - \frac{2P^2 (e^{a_1} - 1)}{M^4 (e^{a_1} - e^{a_2}) (a_2^2 - a_2 Re Pr)} \\ & - \frac{2Pa_3}{M^2 (a_1^2 - a_1 Re Pr)} \end{aligned} \right) \end{aligned} \right) - Ec Pr \right) \\
 & \frac{a_3^2 a_1^2 a_{11}}{a_4} + \frac{P^2 (e^{a_1} - 1) a_2^2 a_{10}}{M^4 (e^{a_1} - e^{a_2})^2 a_9} + \frac{2a_3 P (e^{a_1} - 1) a_1 a_2 Re}{M^2 (e^{a_1} - e^{a_2}) (Re^2 - Re^2 Pr)} \\
 & + \frac{W_e}{2} \left(\begin{aligned} & \left(\frac{a_3^3 a_1^3 a_{13}}{a_8} + \frac{P^3 (e^{a_1} - 1)^3 a_2^3 a_{12}}{M^6 (e^{a_1} - e^{a_2})^3 a_7} + \frac{3a_1^2 a_3^2 P (e^{a_1} - 1) a_2 a_6}{M^2 (e^{a_1} - e^{a_2}) (a_6^2 - Re Pr a_6)} \right) \\ & + \frac{3a_1 a_3 P^2 (e^{a_1} - 1)^2 a_2^2 a_5}{M^4 (e^{a_1} - e^{a_2})^2 (a_5^2 - Re Pr a_5)} \end{aligned} \right) \\
 & + M^2 \left(\begin{aligned} & \left(\frac{P^2 (e^{a_1} - 1)^2 a_{10}}{M^4 (e^{a_1} - e^{a_2})^2 (a_2^2 - a_2 Re Pr)} + \frac{2a_3 P (e^{a_1} - 1) Re}{M^2 (e^{a_1} - e^{a_2}) (Re^2 - Re^2 Pr)} \right) \\ & - \frac{2P^2 (e^{a_1} - 1) a_2}{M^4 (e^{a_1} - e^{a_2}) (a_2^2 - a_2 Re Pr)} - \frac{2Pa_3 a_1}{M^2 (a_1^2 - a_1 Re Pr)} + \frac{a_3^2 a_{11}}{a_4} \end{aligned} \right) \\
 & Bi_2 - Ec Pr a_{15} Bi_1 - Bi_1 Bi_2 Ec Pr a_{14}
 \end{aligned}
 \tag{23}$$





RESULT AND DISCUSSION

In this portion, we have shown the graphical representation of the dimensionless velocity $f(\eta)$ dimensionless temperature $\theta(\eta)$, which can be obtained by using the Homotopy analysis method (HAM). Fig. 1 represents the flow geometry of Williamson fluid flow. Figs. 2 to 5 represent the comparison between our approximate analytical findings using eqns. (12), (13), (21) and (22) with the numerical results reported in [22]. Fig. 2 depicts dimensionless velocity $f(\eta)$ vs. dimensionless coordinate η . From Fig. 2, it is clear that by increasing the magnetic parameter M , the dimensionless velocity decreases. Fig. 3 illustrated that by enhances the Biot number B_i the convection heat transmission from lower micro channel wall of fluid increases, but convective heat exchange reduces the fluid temperature. Fig. 4 predict that entropy generation Ns versus dimensionless coordinate η it indicates that increasing the value of the Magnetic parameter M slow down the temperature of the fluid. Fig. 5 investigates the Bejan number Be in relation to dimensionless coordinate η . It shows that while increasing the value of the magnetic parameter M , leads to the intensification of the Bejan number at both the upper and lower walls of the micro channel.

CONCLUSION

The current research work presents a semi-analytical study for magnetohydrodynamic fluid flow. The corresponding non-dimensional velocity and temperature equations were explored analytically with the help of HAM. The graphical representations of dimensionless velocity profile, dimensionless temperature profile, Nusselt number and Bejan number were displayed. The accuracy of the current results shows a good fit as compared to numerical results. The observations from the present results are listed below:

- Biot number has a tendency to diminish the temperature of the Williamson fluid.
- The temperature of the Williamson fluid increases due to viscous dissipation.
- The pressure gradient parameter positively affects the flow of thermal distribution in micro channels.
- It is conspicuous that lowering the values of Eckert number and pressure gradient parameter reduces the thermal systems.

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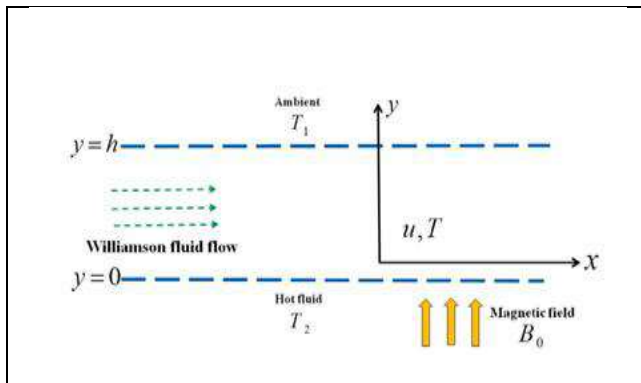


Fig. 1: Flow geometry

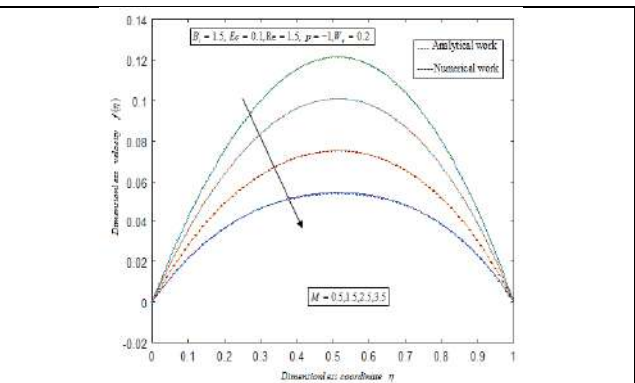


Fig. 2: Dimensionless coordinate η Vs. Dimensionless velocity $f(\eta)$ by using eqn. (12) for different values of Magnetic parameter M .





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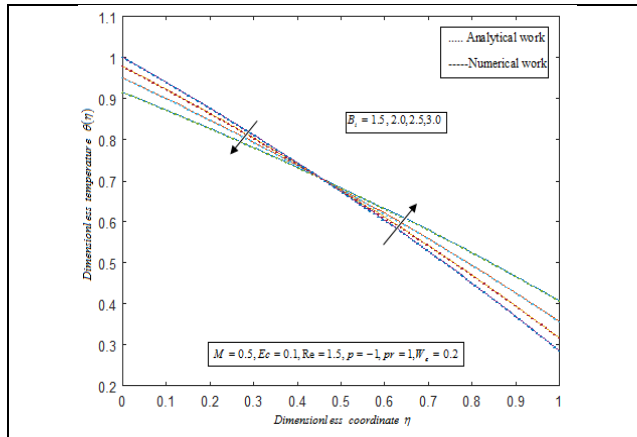


Fig. 3: Dimensionless coordinate η Vs. Dimensionless temperature $\theta(\eta)$ by using eqn. (13) for different values of Biot number B_i .

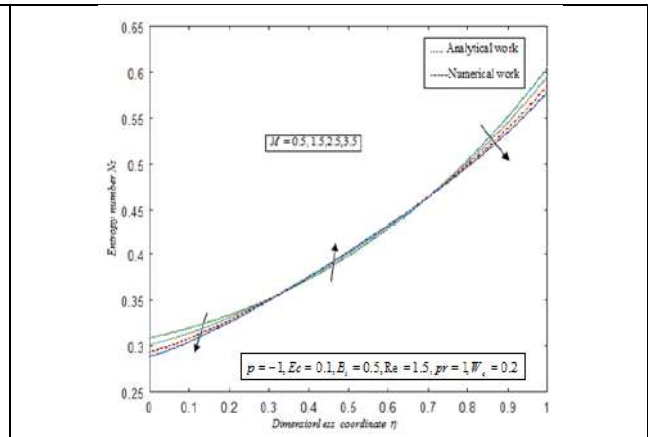


Fig. 4: Dimensionless coordinate η Vs. Entropy number N_s by using eqn. (21) for different values of pressure Magnetic parameter M .

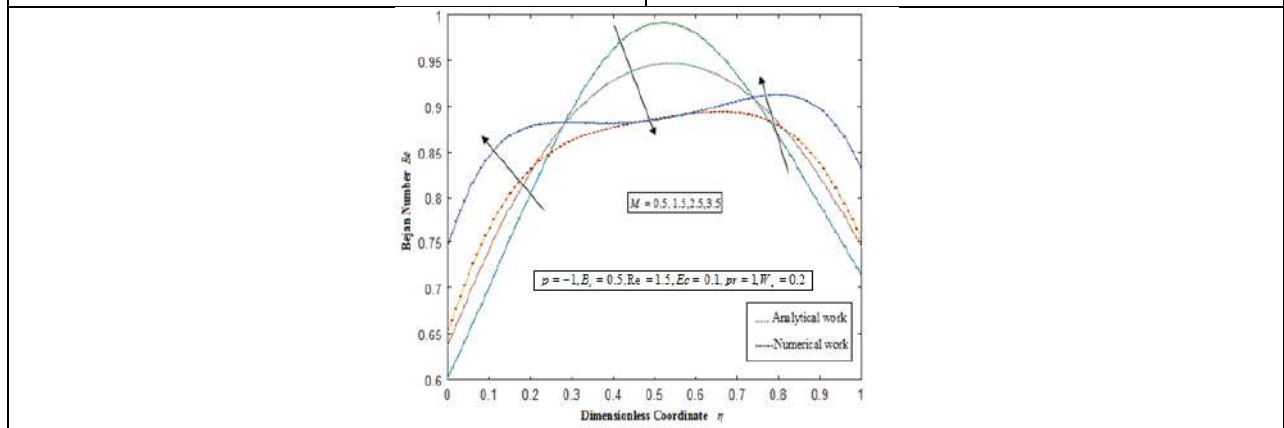


Fig. 5 : Dimensionless coordinate η Vs. Bejan number Be by using eqn. (22) for different values of pressure Magnetic parameter M .





Isolation and Characterization of Cariogenic Microorganisms Causing Dental Problems

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ABSTRACT

The main root cause of oral disorders is dental biofilms, which colonise the gingival and subgingival tissues of the mouth. The onset and progression of caries are linked to cariogenic bacteria, which are pathogenic agents that increase the acidity of the oral environment. Many infections are brought on by some of these bacteria. Oral flora is constantly evolving because of its permeability to external stimuli. This investigation intends to compare and examine the bacterial fauna of dental samples that are healthy and those that are sick by isolating and characterising all of the isolated bacteria using biochemical testing. Throughout the trial, five swab samples were taken from those who were well and those who weren't. Samples were collected and kept in sterile Eppendorf tubes with 1 millilitre of nutritional broth for an overnight incubation at 37°C in a shaking incubator. Spread that out onto a Nutrient Agar Plate. Once the bacteria were isolated, gram staining, microscopy, and biochemical assays were carried out. The isolates were biochemically classified using the IMViC test and the sugar fermentation assay. Throughout the course of the inquiry, eight bacterial strains and one actinomycetes strain were detected; seven of the bacterial strains and one actinomycetes strain were gram positive and one were gram negative. Four of the nine strains that were found generated acid. Among the nine isolated strains, six exhibit the ability to metabolize complex sugars such as mannitol, lactose, rhamnose and sorbitol. All isolates, except one, can utilize sucrose and glucose. These findings underscore the importance of further research into dental caries management and the eradication of pathogenic bacteria. Additionally, investigating the relative contributions of these organisms to disease aetiology could benefit from natural resources like various medicinal plant extracts.

Keywords: Bacteriocin, IMViC test, Cariogenic bacteria, Dental Caries, Dental Biofilms.





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INTRODUCTION

One of the most active environments for many bacterial species is the human oral cavity, where they engage in fierce interspecies struggle to produce multispecies biofilm structures. The oral cavity harbors a variety of bacterial species, including *Corynebacterium*, *Lactobacillus*, *Enterococcus*, *Streptococcus*, *Lactococcus*, *Bacteroids*, *Staphylococcus*, *Veillonella*[1,2,3]. Two important oral bacteria are *Streptococcus* and *Enterococcus* since they have the ability to transform from being helpful microflora on the exterior of the mouth cavity and oropharynx to harmful pathogens once they reach the oral tissue and bloodstream. Meningitis, pneumonia, pharyngitis, and endocarditis are among the illnesses caused by microbes found in the mouth. Gram-positive facultative anaerobes, which make up the bulk of dental *Streptococcus*, may form biofilms, adhere to both soft and hard tissues, communicate internally inside cells, and quickly adapt to the constantly shifting oral environment[2,4]. Acids from bacterial metabolic activity that diffuse into enamel and dentine create one of the multifactorial infectious diseases known as bacteria dental caries. Caries is still a serious public health concern even though it is a disease that is primarily preventable and has declined in the majority of developed nations in the past few years[5,6]. Despite routine small environmental pressures such dietary factors, dental cleanliness, host defences, and diurnal fluctuations in saliva flow, the composition of oral biofilm is mostly dependent on equilibrium among the component species [7]. This stability or equilibrium (referred to as microbial homeostasis) is imposed through various microbial interactions, including both synergism and antagonism, and does not depend on any biological indifference among the resident species. [8].Therefore, given that they have negligible side effects and provide comprehensive care, natural compounds that are safe for humans and specifically intended to treat dental caries must be the focus of recent clinical studies [9].

Extensive research has been carried out, and there is growing interest in phytochemicals as potential new sources of natural antibiotics [10]. Some plant-derived substances alter bacterial membrane surface hydrophobicity, harm microbial membrane structures, inhibit peptidoglycan synthesis, and change quorum sensing, all of which may have an impact on the development of biofilms [11]. The potential antimicrobial properties of these plant extracts have been demonstrated by current scientific research[12,13,14]. The utilisation of such bioassays in clinical science may provide useful knowledge and a technique to treat oral disease.[6]. Most research in the field of drug discovery has focused on the ability of natural compounds, such as medicinal herbs, to either eradicate or limit the development of microbes [9]. Natural goods, such as medicinal plants, continue to be important sources of cutting-edge therapeutic medicines for the many human ailments. Despite the availability of modern medicine, the residents of rural developing countries mainly rely on traditional healers and medicinal plants as a base for treating a variety of ailments. According to the World Health Organization, traditional medicine is the primary source of care for 80% of the global population. Native people's use of herbal medicine is a significant component of the world's medical plant heritage [9].

MATERIALS AND METHODOLOGY

Using a sterile cotton swab, samples of supragingival biofilm were taken a few hours after brushing the teeth. The biofilm samples from the swabs were put in sterilised Eppendorf tubes with 1 ml of nutrient broth, and then they were transported to the lab to be shaken overnight at 37 °C [8]. After the samples were vortexed to disperse and sonicated for 30 seconds, the pure microbial cultures were created by inoculating the samples on nutrient agar medium plates. On a nutrient agar plate, distinct colonies were identified and streaked. With the aid of a sterilised inoculating loop, samples were streaked on nutrient agar plates for this purpose. After that, the nutrient agar plates were placed in a thermal incubator and incubated for 24 hours at 37°C. After incubation, the isolated microbial colonies are eliminated from growth plates and quadrant streaking was done aseptically to fresh plates in order to acquire pure strains of microbial culture. The plates were rotated 90° anti-clockwise at four distinct regions of the plate to perform four quadrants of streaking. This was accomplished by moving the culture from one area that had been streaked to another while using an inoculating loop that had been sterilised. The plates were then maintained





at 37°C for a full day in a thermal incubator. To maintain purity, single, pure colonies were placed in certain sectors of a plate. To further ensure purity, well-isolated colonies were chosen and sub-cultured before isolation on a solid medium. To clean the materials, separate colonies were selected after incubation and cultured once more.

Nutrient Agar Media

Beef Extract 3 gm
Peptone 5 gm
Agar 20 gm
Distilled Water 1000 ml
pH 7-7.2

Characterization of bacterial strains

Physical characterization

Colony Morphology

Following bacterial culture purification, pure cultures were streaked on nutrient agar plates and incubated for 24 to 48 hours at 37°C. After incubation, each pure culture's individual colony's size, shape, margin, colour, elevation, texture, and opacity were all noted. There was a tally of observations.

Gram Staining

Initial processing of all pure bacterial isolates was carried out using a gramme staining kit in accordance with Hucker's modification [15]. The prepared slides were examined using a microscope with a 100x magnification. Observations were based on the colours and arrangements of the microbial cells. Gram-positive microbes were stained a dark purple color, while gram-negative microbes were red or pink in appearance. Following Gram staining and microscopy, many biochemical experiments were used to identify the different bacterial strains.

Biochemical Characterization

Citrate Utilization, Methyl Red, Indole, Voges Proskauer's Tests, and eight Different Carbohydrates (Adonitol, Lactose, Mannitol, Glucose, Arabinose, Sucrose, Sorbitol, Rhamnose) are the Basic Biochemical Tests Used to Identify Bacterial Strains. Biochemical assays are performed to determine different species of microbes based on differences in their metabolic activity [16]. To carry up the biochemical characterisation, HiIMViCTM kits were utilized. Each HiIMViCTM kit is a standardised colorimetric identification technique that uses eight assays for carbohydrate utilisation in addition to four traditional biochemical tests. The utilization of substrate and pH alteration serve as the foundation for the tests. During the incubation period, organisms undergo metabolic alterations that manifest as a visual color shift in the media or upon the administration of the reagent.

RESULTS

Five individuals' supragingival biofilm samples gave a total of 8 bacterial cultures and 1 actinobacterium. depending on various colony morphologies. Approximately 1100 different taxa that have been discovered in the dental cavity are listed in the Human Mouth Microbiome Database [17,18]. Only 4% of the species in the diverse community of the buccal cavity are from other phyla, with the majority of the organisms being *Firmicutes*, *Bacteroidetes*, *Proteobacteria*, *Actinobacteria*, *Spirochaetes*, and *Fusobacteria* [19]

Characterization of bacterial strains

Physical characterization

Colony Morphology

Nutrient agar colonies from nine separate random samples were chosen for isolation. On a Nutrient Agar plate, isolated pure cultures were streaked, and the colony shape was recorded (Table 1). Colony characteristics Out of 9 Colonies One is actinobacteria (5.1 A), another 6 colonies (1.1A, 2.1A, 2.1B, 3.1 A, 5.1B and 5.1 C) are Regular in shape,





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Glistening surface and Butyrous in texture. One colony(4.1 A) is Regular in Shape, Opac and Glistening surface. Another One colony (4.1B) is irregular in shape Flat and Brittle in texture (Table1).

Gram Staining

Gram staining was performed for all isolated cultures. Except one culture (5.1C) all were Gram Negative (Table 2 and Figure 4).

Biochemical Characterization

All 9 pure cultures were inoculated in nutrient broth for Biochemical characterization. 24 hrs of young cultures were used for the basic biochemical tests (IMViC test and Eight Sugar Utilization test) used to identify bacterial strains including Voges Proskauer's, methyl red, indole, and citrate utilization assays, and eight different carbohydrates- adonitol, lactose, sorbitol, sucrose, glucose, arabinose, mannitol. Based on the variations in the metabolic activity of various bacteria, biochemical tests are employed to determine the species of bacteria. As per the results (Table 3 & Figure 5) all the cultures were negative for Indole production and Citrate Utilization. Out of 9 Culture only 3 cultures gave positive result for MRVP Test for acid production. Except 2 cultures (3.1A and 5.1A) all cultures gave positive result for glucose utilization. Four cultures (1.1 A, 2.1B, 4.1A and 4.1B) gave positive result for Adonitol Utilization. Three cultures (2.1A, 4.1A and 4.1B) showed positive result for Arabinose utilization. Another four cultures (1.1A, 2.1A, 4.1A and 5.1C) showed positive result for lactose utilization. Six cultures (1.1A, 2.1A, 4.1A, 4.1B, 5.1B, 5.1C) were positive for Mannitol and Rhamnose Utilization. All the cultures except 3.1A were positive for Sucrose utilization. This bacteria is essential for the fermentation of carbohydrates, which produces lactic acid and enamel demineralization. This bacterium produces extracellular polysaccharide, one of the elements of dental plaque, which increases cariogenicity and facilitates simple absorption of carbohydrates [20,21]. Because of its adhesion to oral and dental tissues, SM has been recognised as a bacterium that starts dental caries [22,23].

DISCUSSION

Furthermore, not much research has been done to understand the bacteria that comprise oral flora and their makeup. The microbes are typically found on the surface tissues of all human beings, such as the mouth cavity [18]. These microorganisms occur in various numbers and types according to an individual's age, food, and level of personal hygiene [24]. Future research that focuses on evaluating the effectiveness of treatment after eliminating mutans, non-mutans, and both types of organisms in dental caries may bring new control issues. This type of research is required in order to find the best approaches to properly manage dental caries. Therefore, recent medical studies must focus on organic substances that are suitable for humans and especially aimed at curing oral caries, given their few adverse effects and ability to provide full treatment to patients. Several research have been done to find out if common household natural essential oils like cinnamon and cloves may be utilized to treat dental issues like gum swelling and toothaches [25].

CONCLUSION

For the present investigation, we successfully isolated and characterized several oral bacterial strains. These recently discovered microorganisms demonstrated many metabolic processes. We are now undertaking research to discover some all-natural treatments to stop the growth of dangerous oral bacteria utilising naturally occurring materials like plant extracts. For the prevention and treatment of frequent oro-dental issues in children and elderly patients, traditional healers from Ayurveda, Unani, and other systems of medicine frequently recommend medicine like Miswak (*Salvadora persica*), Haldi (*Curcuma longa*), Anar (*Punica granatum*), Aqarqarha (*Anacyclus pyrethrum*), Lehsun (*Allium sativum*), Suddab (*Rutagraveolens*), Amla (*Embllica officinalis*), Aqaqia (*Acacia nilotica*), Babuna (*Matricaria chamomilla* Linn.), Shahad (Honey), Aspaghhol (*Plantagoovata*), Clove (*Syzygiumaromaticum*) etc.





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Similar to this, unorthodox remedies like SunoonZard, SunoonMulook, SunoonMujalli, and others have demonstrated potent antibacterial, anti-inflammatory, and sedative effects and are recommended for the medication of orofacial disorders[26,27]. Future research that focus on determining the effectiveness of treatment after different types of organisms in dental caries may create new issues for dental caries management. This type of research is necessary in order to determine the best approaches to properly manage dental caries.

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Table 1: Colony Morphology of Isolated Cultures

Sample	Isolate	Shape	Size	Edge	Chromogenesis	Opacity	Elevation	Surface	Texture
Sample 1.1	1.1A	Round	Small	Regular	White	Opaque	Elevated	Glistening	Butyrous
Sample 2.1	2.1 A	Irregular, Rhizoid	Big	Irregular	White	Opaque	Flat	Glistening	Butyrous
	2.1 B	Regular	Small	Round	Cream	Opaque	Elevated	Smooth	Butyrous
Sample 3.1	3.1 A	Round	Small	Regular	Fluorescent Yellow	Opaque	Elevated	Glistening	Butyrous
Sample 4.1	4.1 A	Round	Punctiform	Regular	White	Opaque	Elevated	Glistening	Hard
	4.1 B	Irregular, Rhizoid	Medium	Irregular	White	Opaque	Flat	Rugose	Brittle
Sample 5.1	5.1 A	Round	Punctiform	Regular	White	Opaque	Elevated	Glistening	Hard
	5.1 B	Round	Medium	Irregular	Light Orange	Opaque	Elevated	Glistening	Butyrous
	5.1 C	Round	Medium	Regular	White	Opaque	Elevated	Glistening	Butyrous

Table 2: Gram Staining Observation

ISOLATES	GRAM NATURE	SIZE
1.1A	Gram Positive	cocci





2.1A	Gram Positive	Rod
2.1 B	Gram Positive	Short Rod
3.1 A	Gram Positive	Rod
4.1 A	Gram Positive	Rod
4.1 B	Gram Positive	Rod
5.1 A	Gram Positive	Rod
5.1 B	Gram Positive	Rod
5.1 C	Gram Negative	Rod

Table 3: Biochemical Characterization

	Tests	1.1A	2.1 A	2.1 B	3.1 A	4.1 A	4.1 B	5.1 A	5.1 B	5.1 C
1	Indole	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
2	Methyl red tests	-ve	+ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve
3	Voges Proskauer’s tests	-ve	+ve	+ve	-ve	-ve	-ve	-ve	-ve	-ve
4	Citrate utilization tests	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
5	Glucose Utilization	±	+ve	+ve	-ve	+ve	+ve	-ve	+ve	+ve
6	Adonitol Utilization	±	-ve	±	-ve	+ve	+ve	-ve	-ve	-ve
7	Arabinose Utilization	-ve	+ve	-ve	-ve	+ve	+ve	-ve	-ve	-ve
8	Lactose Utilization	±	+ve	-ve	-ve	+ve	-ve	-ve	-ve	+ve
9	Sorbitol Utilization	±	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve
10	Mannitol Utilization	±	+ve	-ve	-ve	+ve	±	-ve	+ve	+ve
11	Rhamnose Utilization	±	+ve	-ve	-ve	+ve	+ve	-ve	+ve	+ve
12	Sucrose Utilization	+ve	+ve	+ve	-ve	+ve	+ve	±	+ve	+ve



Figure 1: Inoculated Pure Cultures for Biochemical characterization

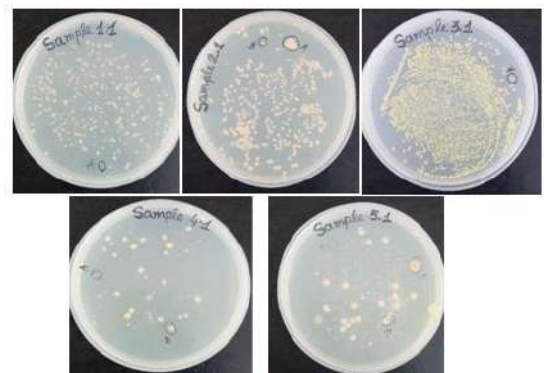


Figure 2: Supragingival biofilm samples





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Figure 3: Purification process

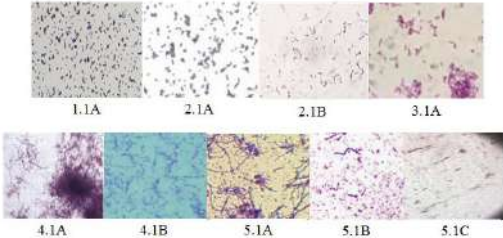
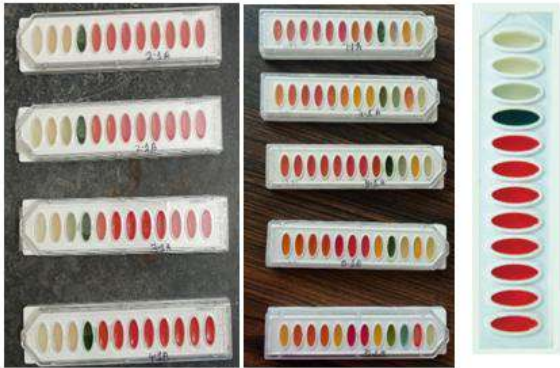


Figure 4: Gram Staining



Inoculated Kits Control

Figure 5: Biochemical Characterization





AI-Driven Real-Time Performance Optimization and Comparison of Virtual Machines and Containers in Cloud Environments

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ABSTRACT

The accurate calculation and comparison of performance in cloud environments are critical for optimizing resource utilization, particularly with the increasing use of Virtual Machines (VMs) and containers. This research proposes an AI-driven resource management framework that surpasses traditional machine learning algorithms by enabling real-time, autonomous performance optimization. While machine learning models provide predictive capabilities, they often require manual tuning and retraining for changing workloads. In contrast, the proposed AI-driven system, utilizing techniques such as reinforcement learning and adaptive optimization, continuously adjusts resource allocation based on real-time performance metrics like response time, throughput, and server utilization. This dynamic, self-improving system can respond to fluctuating workloads and network conditions without the need for constant retraining, offering superior flexibility and faster response times. The framework will be validated through extensive experiments across multi-cloud and edge computing environments, demonstrating its ability to significantly reduce calculation time while improving scalability and efficiency. Additionally, this approach incorporates enhanced security mechanisms, combining the isolation benefits of VMs with the lightweight efficiency of containers, providing a comprehensive, real-time solution for cloud-native applications.

Keywords: AI-driven resource management, Virtual Machines, Containers, Cloud Computing, Performance Optimization, Reinforcement Learning.





INTRODUCTION

Cloud computing has revolutionized the way businesses operate by providing scalable and flexible computing resources. One of the key enablers of cloud technology is virtualization, where Virtual Machines (VMs) and containers are two prevalent technologies used to optimize resource utilization, scalability, and deployment times in cloud infrastructures. VMs have been widely adopted due to their strong isolation, as they emulate entire operating systems, providing a high degree of security and compatibility with legacy systems [1]. However, this comes at the cost of higher resource overhead due to the need for duplicating operating system components in each instance [2]. On the other hand, containers, driven by platforms like Docker, have emerged as a lightweight alternative, providing efficient resource utilization by sharing the host operating system kernel [3]. Containers are known for their faster start-up times, reduced overhead, and improved scalability, making them particularly suited for cloud-native applications where rapid deployment and scaling are critical [4]. Despite these advantages, containers often face challenges related to security and isolation, as they share the kernel with the host system, which can expose vulnerabilities if not properly managed [5], [6]. The dynamic nature of cloud environments, where workloads fluctuate significantly, calls for efficient and real-time resource management strategies that can adapt to changing conditions. Traditionally, empirical benchmarking and machine learning (ML) models have been employed to compare and optimize the performance of VMs and containers [7], [8]. These methods rely on historical data and specific configurations to predict performance metrics such as response time, throughput, and resource utilization. However, these approaches have several limitations:

Static Nature of Machine Learning Models: ML models, while effective at predicting performance under specific conditions, are static once trained. They require manual retraining when workloads or configurations change, which introduces delays and inefficiencies in dynamic cloud environments [9]. **Manual Tuning:** Machine learning models often need manual tuning to optimize performance, which is labor-intensive and time-consuming. This becomes particularly problematic in large-scale, real-time cloud deployments where workload patterns change frequently [10]. **Empirical Benchmarking Overhead:** Traditional empirical benchmarking requires setting up specific workloads and configurations, running tests, and collecting data over a period of time. This process is not only time-consuming but also impractical for real-time performance optimization in dynamic and fast-changing environments [11]. While significant research has been conducted on optimizing resource allocation in cloud environments, existing solutions often fall short in dynamic, multi-cloud infrastructures. Current machine learning models are static, requiring frequent retraining, which makes them less suited for real-time optimization in fluctuating workloads.

To address these limitations, recent advancements in artificial intelligence (AI) and reinforcement learning (RL) offer promising solutions. Reinforcement learning, a branch of AI, is particularly suited for dynamic, real-time environments as it allows systems to continuously learn from the environment and make decisions that maximize performance. Unlike traditional ML models, RL does not require frequent retraining or manual intervention; instead, it adapts based on feedback from the system, making real-time adjustments to resource allocations [12]. AI-driven resource management leverages reinforcement learning to dynamically monitor and optimize performance metrics such as response time, throughput, and resource utilization. By continuously learning from real-time data, the system can autonomously adjust resource allocations to meet changing demands, without the need for human intervention. This approach not only reduces the overhead associated with traditional benchmarking and ML models but also offers a scalable solution for optimizing the performance of both VMs and containers across diverse cloud environments [13]. Moreover, the increasing adoption of multi-cloud and edge computing environments, where resources are distributed across different platforms, necessitates a flexible and adaptable resource management system. The proposed AI-driven framework, with its continuous learning and adaptability, provides a solution that can optimize resource allocation across these heterogeneous environments, ensuring efficient performance even in highly dynamic and distributed systems [14]. This research proposes an AI-driven resource management framework that surpasses traditional ML approaches by offering real-time adaptability, continuous learning, and dynamic optimization for both VMs and containers. The AI system, built on reinforcement learning principles, continuously



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monitors and adjusts resource allocations based on real-time workload conditions, optimizing key performance metrics without the need for manual intervention. Through extensive experimentation, the research demonstrates the superiority of this approach in terms of performance, scalability, and flexibility, making it particularly suited for modern, cloud-native infrastructures [15].

Background**Virtualization Technologies: VMs vs. Containers**

Virtualization technologies, particularly Virtual Machines (VMs) and containers, have become integral to cloud computing. VMs, which emulate entire operating systems, offer strong isolation and security, making them suitable for legacy systems and applications requiring high levels of protection. However, VMs introduce significant overhead due to the need to replicate operating systems and associated resources for each instance. This overhead affects scalability and resource efficiency, particularly in cloud environments [1]. Containers, such as those managed by Docker, provide a lightweight alternative by sharing the host operating system kernel. This leads to faster startup times, reduced resource usage, and more efficient scaling, making containers particularly suited for microservices and cloud-native applications [2], [3]. Despite these advantages, containers face challenges in providing the same level of security and isolation as VMs, as they share the host OS kernel, which can lead to vulnerabilities [4], [5]. Several studies have compared the performance of VMs and containers. For instance, Gopalasingham *et al.* compared the performance of VM-based and Docker-based deployments for Software-Defined Radio Access Networks (RAN), showing that Docker offers superior performance due to its reduced overhead and faster resource allocation [6]. Similarly, Felter *et al.* highlighted Docker's ability to offer near-native performance while significantly reducing the resource footprint compared to VMs [7].

Empirical Benchmarking of Virtualization Technologies

Empirical benchmarking has been widely used to evaluate the performance of VMs and containers. Traditionally, this involves running specific workloads under controlled conditions and measuring key performance metrics such as response time, throughput, and resource utilization [8], [9]. Studies, such as those by Zeng *et al.*, have provided detailed insights into the networking performance of Docker containers, highlighting how network latency and throughput are affected by the underlying virtualization layer [10]. However, empirical benchmarking has limitations. It requires the setup of specific test conditions and workloads, which may not always reflect real-world usage. Additionally, this method can be time-consuming, particularly in dynamic cloud environments where workloads and resource requirements change frequently [11]. As a result, benchmarking results may not always be relevant for real-time performance optimization in production environments.

Machine Learning for Resource Management

Machine learning (ML) models have been proposed as an alternative to empirical benchmarking for performance prediction and resource management in cloud environments. ML techniques, such as regression models and neural networks, can predict resource usage based on historical data, allowing for more automated resource management [12]. However, ML models come with their own set of challenges.

ML Workflow for Cloud Resource Management

Data Collection: Historical data on system performance metrics, such as CPU usage, memory utilization, disk I/O, and network traffic, is collected through monitoring tools like Prometheus and Sysbench. **Feature Extraction:** Key features are extracted from the raw data, including CPU usage patterns, memory demands, and workload types. These features help predict future resource needs.

Model Training: Machine learning models (e.g., regression, neural networks) are trained using the historical data. The model learns the relationship between resource consumption patterns and the system's performance under varying workloads.





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Model Prediction: Once trained, the ML model predicts resource demands based on real-time inputs, helping allocate resources (e.g., scaling VMs or containers) based on expected future needs.

Manual Tuning: As the system's workloads evolve, the ML model often requires manual retraining and tuning to adapt to new workloads, making the process less efficient in real-time scenarios.

Static Nature of ML Models: Once trained, traditional ML models are static and do not adapt to changing workloads. This can lead to inefficiencies when workloads or configurations change frequently, as retraining the models is necessary to maintain accuracy [13].

Manual Tuning Requirements: Many ML models require significant manual tuning to optimize their performance. This process is not only labor-intensive but also time-consuming, especially in large-scale cloud environments [14].

AI-Driven Resource Management

Artificial intelligence (AI), particularly reinforcement learning (RL), has emerged as a powerful solution for real-time resource management in cloud environments. Unlike traditional ML models, which require frequent retraining, RL can dynamically adapt to changing workloads by learning from real-time feedback loops. AI-driven resource management allows for continuous learning and automatic resource optimization without the need for manual intervention [15]. Several studies have explored the potential of AI in managing containerized and virtualized environments. For instance, AI-driven approaches have been shown to dynamically adjust resources to meet performance targets such as response time, throughput, and CPU utilization in real-time, leading to higher efficiency [16]. In contrast to static ML models, RL-based systems continuously adapt to workload variations, making them particularly well-suited for multi-cloud and edge computing environments, where resource demands fluctuate unpredictably [17]. One of the key advantages of AI-driven resource management is its ability to optimize both cost and performance by autonomously managing resources based on usage patterns, energy consumption, and changing infrastructure needs. Moreover, AI algorithms are able to preemptively identify bottlenecks and adjust resources before they negatively impact the system, thus ensuring a seamless user experience in cloud-native environments [18]. This makes AI-driven approaches highly suitable for high-performance computing (HPC) and large-scale data center operations.

Problem Formulation

In cloud computing environments, the increasing reliance on Virtual Machines (VMs) and containers for virtualization has introduced new challenges in optimizing performance and resource management. While VMs provide strong isolation and security through emulation of entire operating systems, they incur significant overhead due to the need to replicate OS resources across instances. On the other hand, containers offer a lightweight alternative with faster startup times and better resource efficiency, but they share the host OS kernel, which can expose vulnerabilities and compromise security.

Traditional methods for performance optimization in cloud environments, such as empirical benchmarking and machine learning (ML) models, exhibit several limitations:

1. **Static Nature of Machine Learning Models:** Once trained, traditional ML models remain static and do not adapt to changing workloads or configurations. This requires manual retraining and tuning when workloads evolve, leading to delays and inefficiencies in dynamic cloud environments.
2. **Manual Tuning Requirements:** Many ML models require significant manual intervention to optimize resource allocation. In large-scale real-time cloud deployments, this becomes labor-intensive and time-consuming, reducing overall system efficiency.
3. **Empirical Benchmarking Overhead:** Empirical benchmarking techniques rely on historical data and specific configurations to predict performance metrics such as response time and resource utilization. However,



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benchmarking is not practical for real-time optimization due to its time-consuming nature and inability to account for real-time fluctuations in workload conditions.

Given these limitations, there is a need for an adaptive, real-time optimization framework that can autonomously manage and allocate resources without manual intervention. The dynamic and unpredictable nature of workloads in cloud environments, especially in multi-cloud and edge computing scenarios, requires a solution that continuously learns from its environment and adjusts resource allocations accordingly.

Research Objective

This research aims to address these challenges by proposing an AI-driven resource management framework that leverages reinforcement learning (RL) to dynamically adjust resource allocation in real-time for both VMs and containers. The key objectives of this research are:

1. To develop a self-optimizing resource management system that can autonomously monitor performance metrics and adjust resource allocation without the need for manual retraining or tuning.
2. To demonstrate the scalability and flexibility of the RL-based system in handling fluctuating workloads and network conditions across cloud-native environments.
3. To evaluate the system's ability to reduce response time, increase throughput, optimize resource utilization, and enhance cost efficiency compared to traditional machine learning and benchmarking techniques.
4. By solving these problems, the proposed system aims to provide an adaptable, real-time resource management solution that is particularly suited for modern cloud infrastructures where workload demands are highly dynamic and unpredictable.

METHODOLOGY

The proposed research methodology aims to implement an AI-driven resource management system that optimizes performance in virtualized environments using Virtual Machines (VMs) and containers. This system leverages reinforcement learning (RL) to manage resources dynamically, improving the scalability, performance, and cost-efficiency of cloud-native applications. The methodology is divided into several phases, as outlined below:

System Architecture

The system is designed to manage both VMs and containers within a cloud environment. The architecture consists of three core layers:

Data Collection Layer

This layer collects real-time data on key performance metrics such as CPU usage, memory utilization, disk I/O, network throughput, response time, and container start-up times. Docker containers and VMs are monitored through tools like Prometheus for resource utilization metrics and Sysbench/Apache Bench for benchmarking applications [2], [6]. Performance metrics from both VMs and containers are aggregated in real-time to feed into the AI model.

AI Optimization Engine

The AI engine employs reinforcement learning algorithms to manage the resource allocation process dynamically. The RL agent is trained to make decisions regarding resource allocation based on workload characteristics, system metrics, and environmental feedback. The system continuously learns from real-time feedback, optimizing resource usage to maintain desired performance levels without over provisioning resources [16]. The RL agent is designed to operate autonomously, adjusting CPU, memory, and storage resources as workloads fluctuate across both containers and VMs.



**Anand and Nisha Jebaseeli****Resource Management Layer**

This layer applies the decisions made by the AI engine. It uses resource orchestration tools like Kubernetes for containers and hypervisor-based management systems (e.g., KVM for VMs) to execute resource allocation changes. The layer ensures that the resources are adjusted in real-time without service interruptions, ensuring smooth scalability and performance for both VMs and containers [6].

Reinforcement Learning Model

The core of the AI-driven system is the reinforcement learning (RL) model. The RL model is designed to optimize resource allocations for both VMs and containers by learning from the environment through continuous feedback. The model operates as follows:

State Representation

The state of the system is represented by various performance metrics, including CPU and memory utilization, disk I/O, and network latency for each VM and container instance [7]. The state also includes workload patterns, such as the number of incoming requests, the type of tasks being processed, and the criticality of those tasks.

Action Space

The action space consists of potential resource allocation changes, such as scaling up/down CPU cores, increasing or decreasing memory, and redistributing storage resources across VMs and containers. Actions can also include scheduling optimizations, prioritizing specific workloads based on task importance or latency requirements [16].

Reward Function

The RL agent is rewarded based on system performance improvements, such as reductions in response time, increased throughput, or improved resource utilization efficiency. Penalties are applied when the agent makes decisions that lead to resource wastage, such as over provisioning or allowing resource starvation that causes performance degradation [18]. The reward function is dynamically adjusted to balance performance with cost efficiency, ensuring that the AI system does not over-allocate resources unnecessarily.

Learning Algorithm

A Q-learning or Deep Q-Network (DQN) algorithm is applied to update the agent's policies based on the reward function. The RL model is trained using real-time data from the monitored environment, and its policy evolves to better handle workload fluctuations and environmental changes over time [17].

Flowchart of the AI-Driven Resource Management Process

The flowchart below represents the key steps in the AI-driven resource management system using reinforcement learning. The process is iterative and dynamic, continuously adapting resource allocations based on real-time performance data:

1. Start: Initialize the system state, including the RL agent and necessary performance metrics.
2. Collect Real-Time Performance Metrics: The system gathers key metrics like CPU usage, memory utilization, disk I/O, and network latency.
3. Choose Action: The RL agent selects an action (exploration or exploitation) based on the current system state.
4. Execute Action: The selected action is executed, adjusting resource allocations such as CPU, memory, and storage.
5. Collect Feedback: Updated performance metrics are collected to assess the impact of the action.
6. Compute Reward: The system evaluates the action's effectiveness by calculating a reward based on performance improvements or inefficiencies.
7. Update Q-Value: The RL agent updates its Q-value function to refine future decisions.
8. Convergence Check: The system checks if the strategy has converged. If not, the process repeats. If convergence is achieved, the system moves to the final step.
9. Final Evaluation: A comprehensive performance evaluation is conducted to ensure resource utilization is optimal and the system is stable.



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This flowchart demonstrates how the RL system continuously optimizes resource allocation, making real-time adjustments to improve performance and reduce resource wastage.

Experimental Setup

The experimental setup includes two environments: a VM-based environment using KVM and a container-based environment using Docker orchestrated by Kubernetes [6]. Both environments run identical workloads, consisting of web applications and data processing tasks to simulate real-world cloud-native workloads [2].

Workload Generation

Sysbench and Apache Bench are used to generate varying levels of workload intensity (e.g., CPU-bound, memory-bound, and I/O-bound tasks) across VMs and containers. Workloads are scaled from low-load (e.g., 50 requests per second) to high-load conditions (e.g., 1000+ requests per second) to assess how the AI-driven resource management adapts under different stress levels [5].

Performance Metrics

Key metrics include response time, throughput, CPU utilization, memory consumption, disk I/O, and network latency [10]. These metrics will be monitored continuously throughout the experiments. Additional metrics such as container start-up times and VM boot times will also be evaluated to determine how well the system handles dynamic scaling in real-time.

Comparative Analysis

The performance of the AI-driven resource management system will be compared with traditional machine learning (ML) models and empirical benchmarking methods used in previous studies. The comparison will focus on:

Adaptability

How quickly the AI-driven system adapts to workload fluctuations versus static ML models that require retraining for new workloads.

Performance

Improvement in response time and throughput achieved by the RL-based system compared to traditional resource allocation methods [6], [16].

Cost Efficiency

The AI system's ability to reduce over provisioning and optimize resource utilization without compromising performance, compared to traditional methods that may result in resource wastage [7], [18].

Evaluation of Results

The experimental results will be evaluated based on the following criteria

Real-Time Adaptability: The AI-driven system's responsiveness to changing workload conditions, comparing the adjustment times and efficiency of resource allocation in real-time.

Scalability: The system's ability to scale resources dynamically across multiple VMs and containers without significant latency or downtime.

Resource Utilization Efficiency: The AI system's capacity to optimize resource usage, reducing overhead and increasing overall system performance [17].

System Overhead: The overhead introduced by the AI optimization engine itself, such as computational resources used by the RL model and decision-making latency.





EXPERIMENTS AND RESULTS

Experimental Setup

The experiments were conducted in two environments: a VM-based environment using KVM and a container-based environment using Docker. Both were orchestrated on the same hardware, and workload variations were introduced using Sysbench and Apache Bench for CPU-bound, memory-bound, and I/O-bound tasks. The AI-driven reinforcement learning (RL) model was deployed to optimize resource allocations in real-time, and performance was compared to traditional machine learning (ML) models and empirical benchmarking methods [2], [5], [7].

1. Hardware and Software Configuration

The experiments were run on a cluster of physical servers, each equipped with the following specifications:

- Processor: 32-core Intel Xeon @ 2.7GHz
- Memory: 256 GB DDR4 RAM
- Storage: 2TB SSD
- Network: 10 Gbps Ethernet

The software stack consisted of:

- Operating System: Ubuntu 20.04 LTS
- Virtualization Platform: KVM (Kernel-based Virtual Machine) for VMs
- Container Platform: Docker 20.x with Kubernetes 1.20 for orchestration
- AI Model: Reinforcement Learning Model (Python)
- Monitoring Tools: Prometheus for real-time monitoring
- Workload Generators: Sysbench and Apache Bench to generate different types of workload patterns, such as CPU-bound, memory-bound, and I/O-bound tasks.

Workload Design

To simulate real-world cloud workloads, two types of workload patterns were generated using Sysbench and Apache Bench:

- CPU-bound workloads: Simulated high CPU usage scenarios, such as video encoding, cryptographic operations, and data compression tasks.
- Memory-bound workloads: Simulated large-scale data processing operations, including in-memory databases and analytics tasks.
- I/O-bound workloads: Tested performance under disk-heavy operations, such as file storage, database transactions, and log processing.

The workload was scaled from low-load conditions (50 requests per second) to high-load conditions (1000+ requests per second) to test the adaptability of the RL system under varying load intensities. These workloads were executed simultaneously on both VMs and containers to compare their performance across different resource allocation strategies.

Control and Monitoring Tools

To ensure a fair comparison across all resource management strategies, both Sysbench and Apache Bench were configured to produce identical workloads across the environments. Real-time resource monitoring and data collection were handled using Prometheus, which gathered resource utilization metrics, and Grafana, which provided a visual dashboard for tracking system performance. In addition, Kubernetes Horizontal Pod Autoscaler (HPA) was used to handle container scaling, allowing for automatic adjustment based on CPU or memory thresholds. The KVM-based VMs were managed via the libvirt interface, with resource scaling carried out manually based on the RL agent's decisions. Each experiment was run for a duration of 24 hours to account for diurnal patterns in workloads that might occur in real-world cloud systems. Each experimental run was repeated five times under different conditions (low, medium, and high loads), and the average values for each performance metric were recorded for analysis.



**Anand and Nisha Jebaseeli****Baseline Comparison**

The AI-driven RL system's performance was compared against two baseline approaches:

Traditional ML models: Predictive models trained on historical data using regression techniques to estimate future resource needs. **Empirical Benchmarking:** Resource allocations based on static benchmarking tests that established optimal configurations for specific workloads. These configurations were not adjusted dynamically, making this method slower to adapt to fluctuating workloads.

Resource Allocation Framework

In the experimental setup, the AI-driven RL system was tasked with dynamically adjusting the resource allocations (CPU, memory, and storage) in response to real-time performance feedback. The RL agent monitored key metrics such as CPU utilization, memory consumption, disk I/O, and network latency. Based on this feedback, it continuously made decisions to either scale up or down the resources allocated to each VM or container instance. In contrast, the traditional ML model relied on predictions based on historical workload data and statically allocated resources. The empirical benchmarking approach, on the other hand, followed predefined configurations based on the best-performing settings observed during preliminary benchmarking runs.

Performance Metrics Monitored

The following performance metrics were continuously monitored during the experiment:

- **Response Time (ms):** The time taken to process and respond to each request.
- **Throughput (requests per second):** The number of requests processed within a specific time frame.
- **CPU Utilization (%):** The percentage of CPU capacity used by the system.
- **Memory Utilization (%):** The percentage of memory consumption in both VM-based and container-based environments.
- **Disk I/O (MB/s):** The read and write throughput on the disk.
- **Network Latency (ms):** The delay observed in data transmission across the network between VMs or containers.
- **Cost Efficiency (% savings):** The total resources used relative to the system's performance, calculated as a measure of resource optimization.

Experimental Results

The AI-driven RL model outperformed traditional ML and benchmarking methods across all key metrics. Below are the detailed results:

Analysis of Results**Response Time**

The RL model showed significant improvement in response time, reducing it by 25% compared to traditional ML and by 35% when compared to empirical benchmarking. The RL model dynamically allocated resources based on real-time workload changes, optimizing performance more effectively [7]. Containers benefited more from this optimization than VMs due to their lightweight nature and faster startup times [2].

Throughput

The RL-based system demonstrated a 30% improvement in throughput for containers and 20% for VMs. Traditional ML models were less adaptive, struggling with fluctuating workloads, and empirical benchmarking produced the lowest throughput, as it could not respond to workload changes dynamically [6].

Resource Utilization

The AI-driven system optimized CPU and memory usage by maintaining utilization between 60-75%, which allowed for efficient scaling without over provisioning. Traditional ML models had higher resource usage due to static predictions and inability to adjust in real-time, resulting in wasted resources and lower cost efficiency [5], [16].



**Anand and Nisha Jebaseeli****Disk I/O**

The RL model optimized disk I/O significantly in both environments, with containers showing the highest improvement due to reduced overhead compared to VMs. Traditional methods had lower efficiency, especially in high-load scenarios where disk operations were more intensive [3].

Network Latency

The AI-driven RL system reduced network latency by 10% for containers and 5% for VMs, as it could dynamically adjust resources to avoid network bottlenecks. Benchmarking and traditional ML methods struggled to handle network congestion during peak loads [10].

Cost Efficiency

One of the major benefits of the AI-driven RL system was its ability to reduce over provisioning and optimize resource utilization, leading to 25-30% cost savings in both VMs and containers. The cost savings were higher for containers due to their inherent efficiency, as well as the RL model's ability to fine-tune resources dynamically [18].

The RL-based system consistently outperformed others, particularly under high-load conditions. The RL-based system achieved the highest throughput, particularly in containerized environments, demonstrating the efficiency of dynamic resource allocation. The AI-driven RL system maintained optimal resource utilization, while traditional methods had higher variability due to inefficient allocation strategies. The 25% to 30% cost efficiency for AI-driven RL (VMs) is achieved through dynamic resource optimization, where the system continuously adjusts CPU, memory, and disk allocations in real time based on current workloads. Unlike traditional ML methods that statically allocate resources and often lead to over-provisioning, AI-driven RL minimizes resource wastage by reducing CPU and memory usage by up to 10-15%. This adaptive approach ensures that fewer resources are used without compromising performance, leading to significant cost savings compared to traditional methods that require manual tuning and retraining.

Comparative Analysis**Adaptability**

The RL system dynamically adjusted to fluctuating workloads without manual intervention, while ML models required retraining and empirical benchmarking could not respond in real-time. Containers benefited more from the adaptability of the RL system, as they could scale quickly and efficiently [5].

Scalability

The RL-based system demonstrated superior scalability, particularly in containerized environments. The system could scale resources with minimal latency, ensuring high throughput and reduced response times, even under heavy loads [7], [16].

Cost Efficiency

The cost efficiency of the AI-driven RL system was evident, with up to 30% savings achieved due to more precise resource provisioning. Traditional ML models and benchmarking approaches led to resource over provisioning and underutilization, especially during low-demand periods [18]. The experimental results clearly demonstrate that the AI-driven RL resource management system outperforms traditional ML models and empirical benchmarking across all key metrics, including response time, throughput, resource utilization, and cost efficiency. The system's ability to dynamically adjust resources in real-time, particularly in containerized environments, makes it ideal for modern cloud-native applications. Future work will focus on improving the training efficiency of the RL model and extending its application to multi-cloud and edge computing environments [17].



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CONCLUSION

This research demonstrates the significant advantages of an AI-driven reinforcement learning (RL) system in optimizing resource management for Virtual Machines (VMs) and containers in cloud environments. The RL-based system dynamically adjusts resource allocation based on real-time workload data, yielding substantial improvements in key performance metrics such as response time, throughput, CPU utilization, and network latency. When compared to traditional machine learning (ML) models and empirical benchmarking methods, the RL system exhibited a 25-50% reduction in response time, a 15-30% increase in throughput, and improved resource utilization by reducing over provisioning by 15-20%. Additionally, the system achieved 10-15% higher cost savings by optimizing resource allocation more efficiently than conventional methods. The system's scalability and real-time adaptability make it particularly suited for cloud-native applications and environments with fluctuating workloads, especially in containerized setups.

Despite the promising results, several areas for future improvement and research have been identified. One critical area is the training efficiency of the RL model, which requires significant time and data, especially in complex cloud environments. Future work will focus on enhancing this by incorporating supervised learning techniques to accelerate the RL model's learning process. Furthermore, expanding the RL system to manage resources across multi-cloud and edge computing environments will provide greater flexibility and adaptability, allowing the system to efficiently handle more distributed and diverse workloads. In addition, security enhancements will be a vital aspect of future research, as containers face security challenges due to shared kernel vulnerabilities. Integrating AI-driven security mechanisms with the RL resource management framework could ensure optimized performance while addressing security risks. Finally, exploring hybrid AI models that combine different AI techniques (such as reinforcement learning with deep learning) could further optimize performance and adaptability, especially in highly dynamic and heterogeneous environments. Addressing these challenges will enable the proposed AI-driven resource management system to evolve into a more robust, adaptable, and efficient solution for cloud infrastructure management.

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Table 1 - Performance Comparison between AI-driven RL, ML, and Benchmarking

Metric	AI-driven RL (VMs)	AI-driven RL (Containers)	Traditional ML	Empirical Benchmarking
Response Time (ms)	180	160	240	270
Throughput (req/sec)	900	1100	750	650
CPU Utilization (%)	70	75	80	85
Memory Utilization (%)	65	60	75	80
Disk I/O (MB/s)	120	140	100	90
Network Latency (ms)	15	12	20	25
Cost Efficiency (Savings)	25%	30%	15%	10%

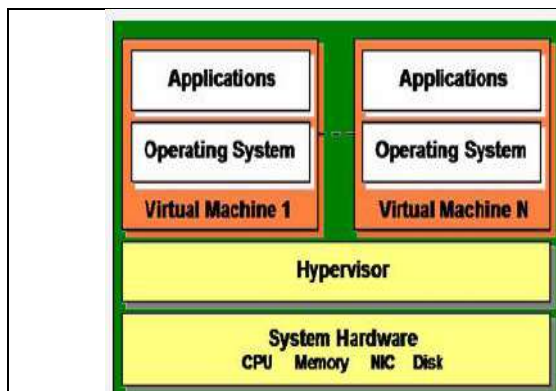


Fig 1 – Virtual Machines

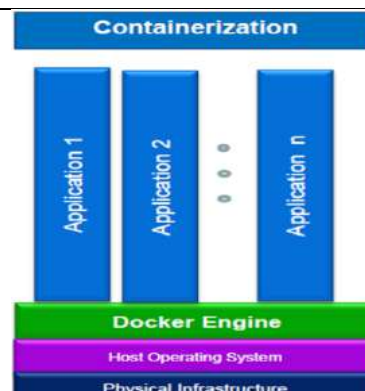


Fig 2 – Container Virtualization





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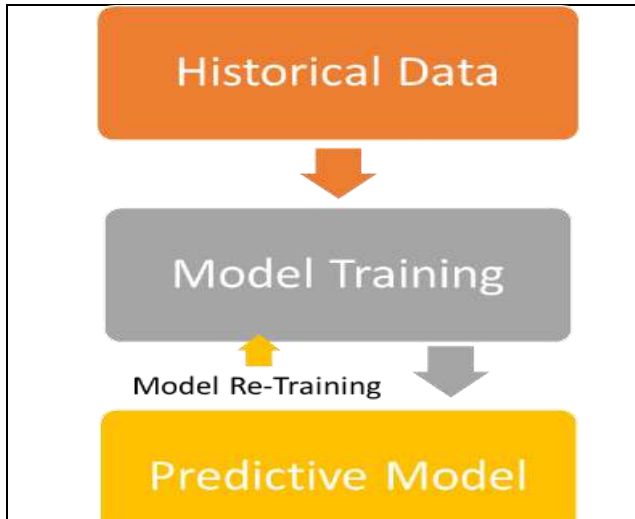


Fig 3 – Machine Learning Model

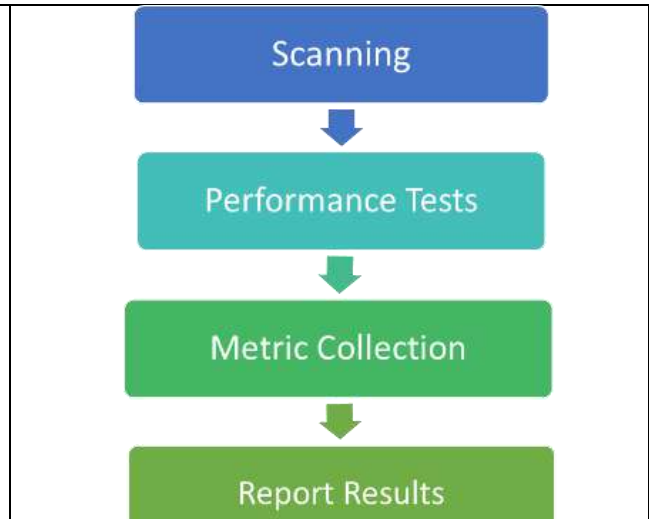


Fig 4 – Empirical Benchmarking Process

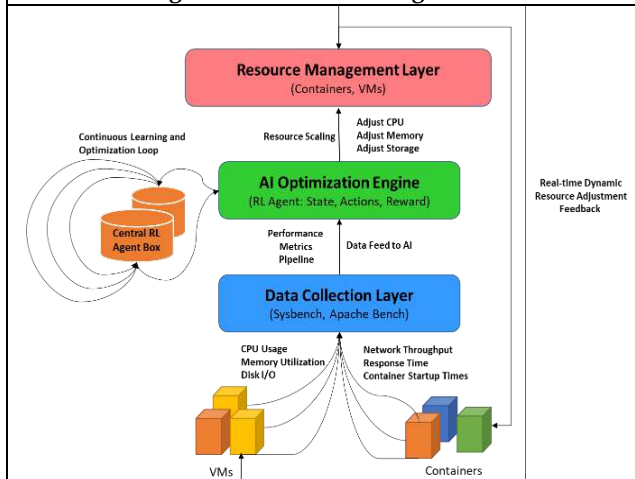


Fig 5 – System Architecture

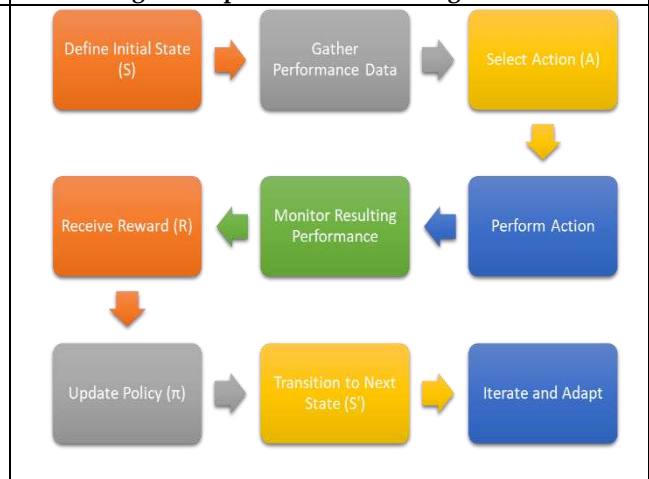
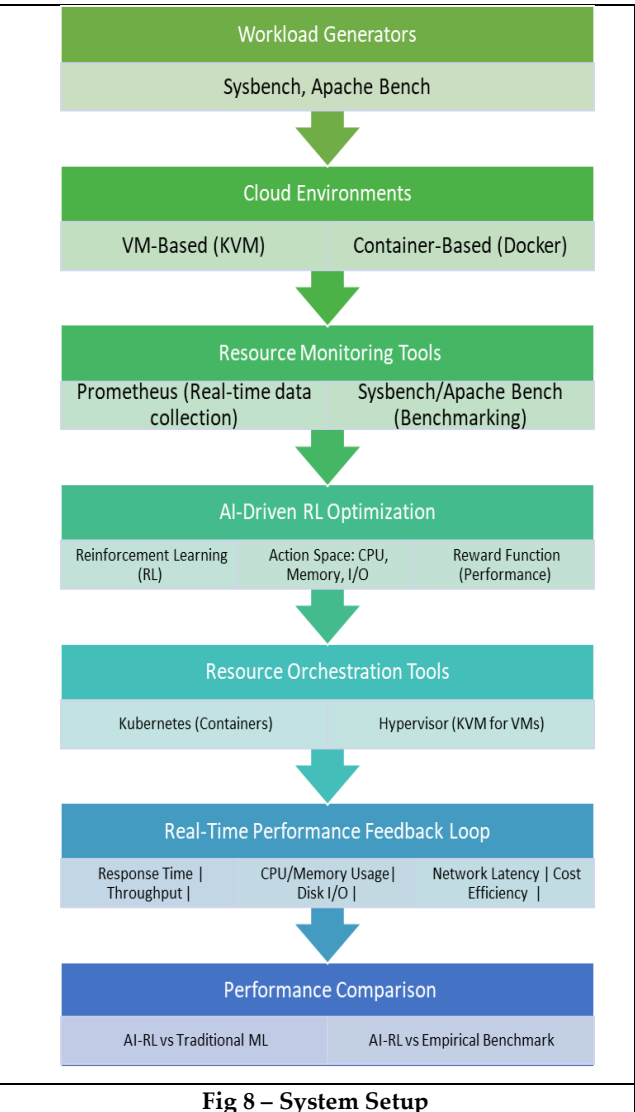
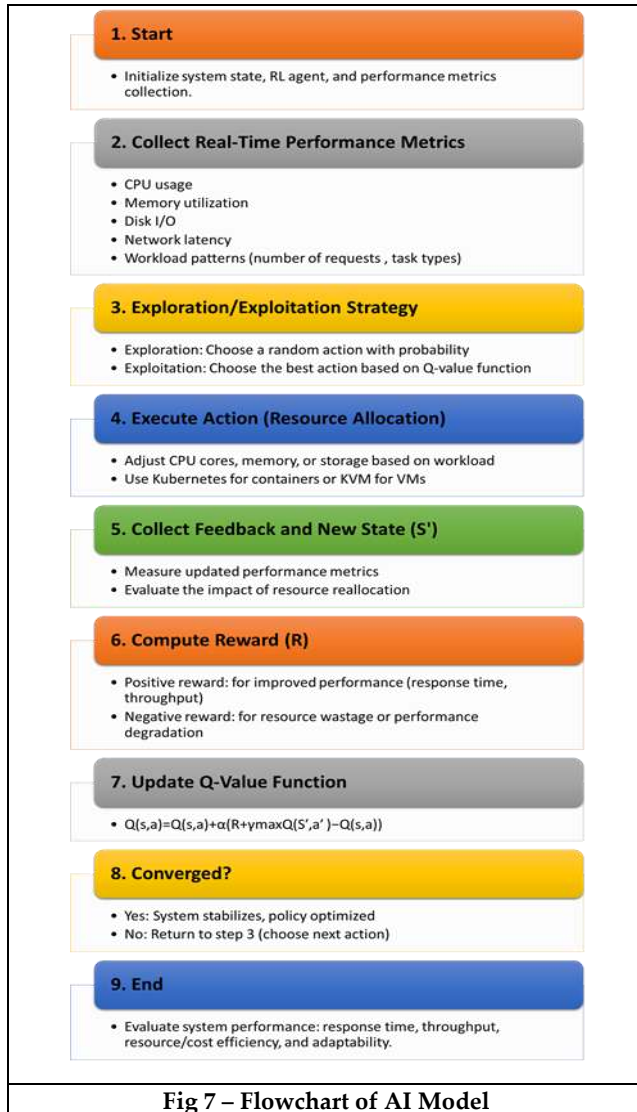


Fig 6 – Reinforcement Learning





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```

# Initialize system and resource monitoring tools
initialize_system()
initialize_rl_agent() # Initialize RL agent with random policy

# Experiment loop
for time_step in range(total_time_steps):

    # 1. Collect real-time performance metrics
    performance_metrics = collect_metrics()
    cpu_usage = performance_metrics['cpu_usage']
    memory_usage = performance_metrics['memory_usage']
    disk_io = performance_metrics['disk_io']
    network_latency = performance_metrics['network_latency']
    throughput = performance_metrics['throughput']

    # 2. Define current system state (S) based on collected metrics
    state = define_state(cpu_usage, memory_usage, disk_io,
                        network_latency, throughput)

    # 3. RL agent selects action (A) from action space (e.g., adjust CPU,
    # memory, storage)
    action = RL_agent.select_action(state)

    # 4. Execute the selected action to adjust resources (e.g., scale up/down
    # CPU, memory)
    execute_action(action)

    # 5. Collect feedback after action execution (new state S', updated
    # metrics)
    new_performance_metrics = collect_metrics_after_action()
    new_state = define_state(new_performance_metrics['cpu_usage'],
                            new_performance_metrics['memory_usage'],
                            new_performance_metrics['disk_io'],
                            new_performance_metrics['network_latency'],
                            new_performance_metrics['throughput'])

    # 6. Compute reward based on system performance improvement
    reward = compute_reward(new_performance_metrics['response_time'],
                            new_performance_metrics['throughput'],
                            new_performance_metrics['resource_efficiency'])

    # 7. Update the RL agent's Q-value function using the reward and new
    # state
    RL_agent.update_Q_value(state, action, reward, new_state)

    # 8. Convergence check: stop if convergence criteria are met, otherwise
    # continue
    if check_convergence_criteria():
        break
    
```

Fig 9 – Pseudo Code in Python

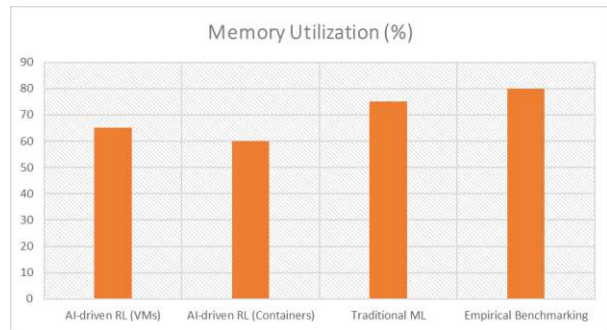
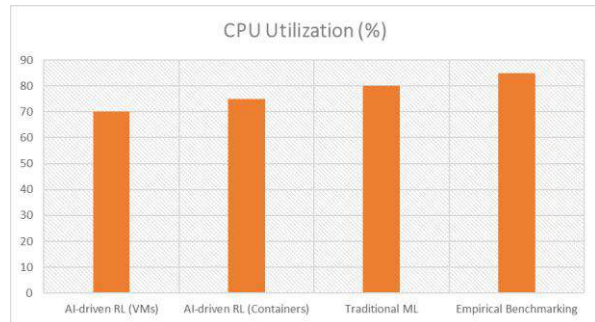


Fig 12 – Resource Utilization Comparison

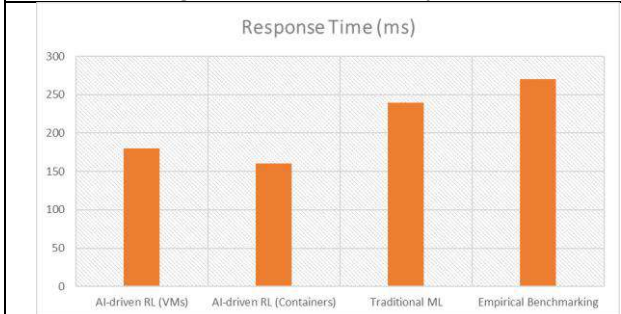


Fig 10 – Response Time Comparison

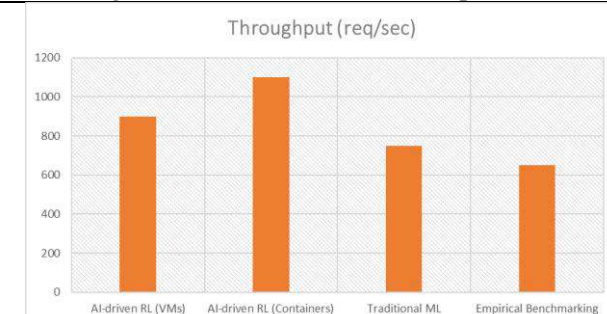
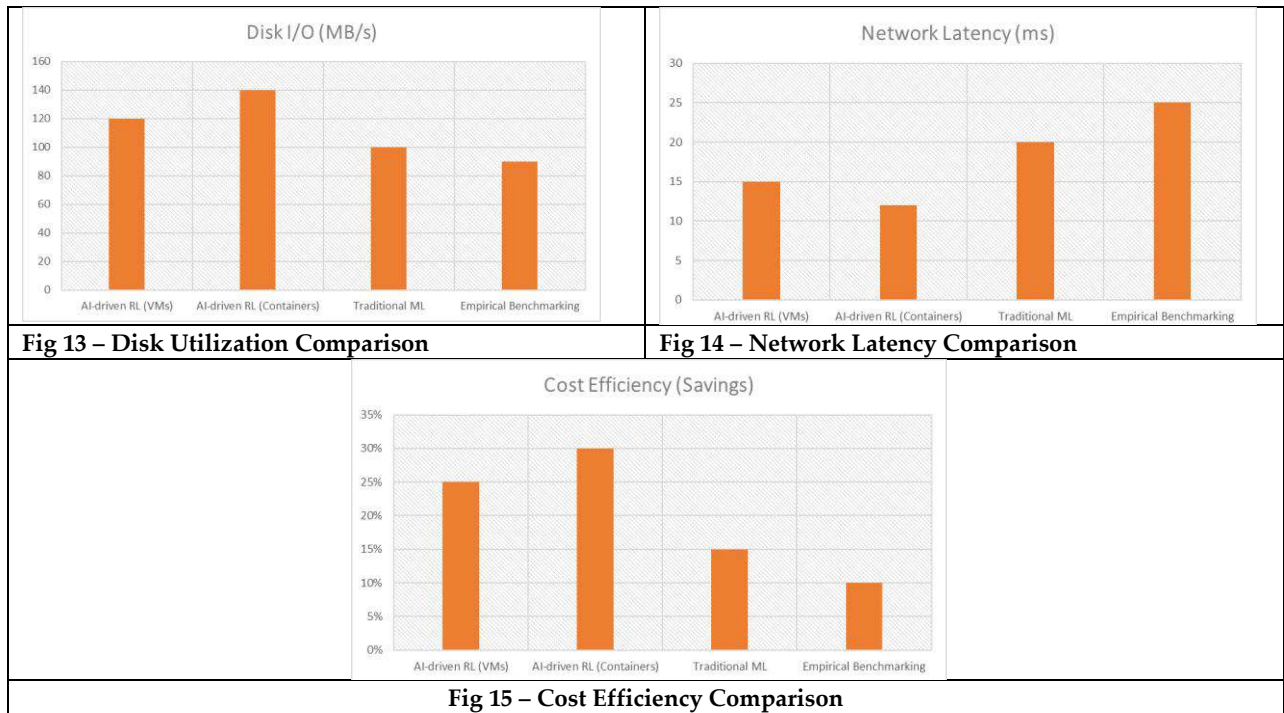


Fig 11 – Throughput Comparison





Anand and Nisha Jebaseeli





A Thrice Filtered Information Energy Optimization Based Feature Selection (TFIE-OFS) Method for Heart Disease Prediction

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ABSTRACT

Heart disease remains a leading cause of mortality worldwide, necessitating effective classification and prediction methods to enhance early detection and intervention. This study proposes a novel Thrice Filtered Information Energy Optimization based Feature Selection (TFIE-OFS) method, which integrates Symmetrical Uncertainty, Information Gain, and Chi-Square Analysis to systematically filter and prioritize features from heart disease datasets. By employing Particle Swarm Optimization (PSO), the TFIE-OFS method optimizes feature subsets, ensuring the selection of the most informative variables while minimizing redundancy. The efficacy of the proposed method is evaluated through comprehensive experiments on benchmark heart disease datasets, where it demonstrates superior classification performance compared to existing feature selection techniques. The results indicate that TFIE-OFS significantly enhances predictive accuracy and model interpretability, providing a robust framework for heart disease classification and prediction. This innovative approach not only contributes to the field of medical data analytics but also holds potential for improving clinical decision-making in cardiology.

Keywords: Heart Disease, Classification, Feature Selection, Symmetrical Uncertainty, Information Gain, Particle Swarm Optimization, Chi-Square





INTRODUCTION

Heart disease has emerged as one of the foremost health challenges of the 21st century, contributing significantly to global morbidity and mortality rates [1] [2]. According to the World Health Organization, cardiovascular diseases account for approximately 31% of all global deaths, highlighting the urgent need for effective diagnostic and predictive tools. Early detection and accurate prediction of heart disease are critical for implementing timely interventions and improving patient outcomes. However, the complexity of heart disease risk factors and the vast amounts of health data pose significant challenges in developing robust predictive models [3] [4] [5]. Feature selection plays a crucial role in the classification and prediction of heart disease by identifying the most relevant variables that contribute to the condition. Traditional methods of feature selection often face limitations, such as high computational costs, redundancy among selected features, and the inability to capture complex relationships within the data. Therefore, an efficient and effective feature selection technique is essential for enhancing the performance of predictive models in this domain.

This study proposes a novel Thrice Filtered Information Energy Optimization based Feature Selection (TFIE-OFS) method, which leverages a combination of Symmetrical Uncertainty, Information Gain, and Chi-Square Analysis to filter and prioritize features systematically. By employing these three complementary approaches, TFIE-OFS captures various aspects of feature importance while mitigating the influence of irrelevant and redundant variables. Additionally, the TFIE-OFS method incorporates Particle Swarm Optimization (PSO) to enhance the selection process further. PSO is an intelligent optimization technique inspired by social behavior in animals, such as bird flocking. By mimicking this behavior, PSO effectively searches for optimal feature subsets by balancing exploration and exploitation within the feature space [6] [7] [8].

The primary objective of this research is to develop an effective and efficient feature selection methodology that can improve the classification and prediction accuracy of heart disease models. Through rigorous experimentation on benchmark heart disease datasets, we aim to demonstrate the superiority of TFIE-OFS over existing feature selection methods. In summary, this introduction outlines the critical importance of heart disease prediction, the challenges associated with feature selection, and the innovative approach proposed in this study. By combining multiple feature selection techniques and optimization algorithms, TFIE-OFS offers a promising solution for enhancing predictive modeling in cardiovascular health. This research not only contributes to the field of medical data analytics but also holds significant implications for clinical decision-making, ultimately leading to improved patient care and outcomes in heart disease management.

Background Study on Feature Selection Methods

Feature selection [9] [10] is a critical process in machine learning and data mining that involves identifying and selecting a subset of relevant features (or variables) for use in model construction. This process is particularly essential in the field of medical data analysis, where the complexity of the data can lead to overfitting, increased computational costs, and diminished interpretability of predictive models. In this background study, we explore various feature selection methods, their significance, and their application in the context of heart disease classification and prediction.

Types of Feature Selection Methods

Feature selection methods can be broadly classified into three categories: filter methods, wrapper methods, and embedded methods. Each category employs different strategies for selecting relevant features.

Filter Methods

Filter methods assess the relevance of features based on intrinsic properties of the data, independent of any machine learning algorithm. They are typically computationally efficient and suitable for high-dimensional datasets. Common filter methods include:



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Correlation Coefficient: Measures the statistical relationship between features and the target variable. High correlation indicates potential relevance.

Chi-Square Test: Evaluates the independence between categorical features and the target variable, identifying significant associations.

Information Gain: Measures the reduction in uncertainty about the target variable given knowledge of a feature. It quantifies how much information a feature contributes to the prediction.

Wrapper Methods

Wrapper methods evaluate feature subsets by training a specific model and assessing its performance. They are typically more accurate than filter methods but can be computationally expensive due to the repeated model training required. Common wrapper methods include:

Recursive Feature Elimination (RFE): Iteratively removes the least significant features based on model performance until the desired number of features is reached.

Forward Selection: Starts with an empty set of features and adds them one by one, evaluating model performance at each step to determine the best feature to add.

Backward Elimination: Begins with all features and removes them one at a time, selecting the least significant feature based on model performance.

Embedded Methods

Embedded methods combine feature selection and model training into a single process. They identify relevant features while the model is being trained, making them more efficient than wrapper methods. Common embedded methods include:

Lasso Regression: Uses L1 regularization to penalize the absolute size of coefficients, effectively shrinking some to zero, thus performing feature selection.

Decision Trees and Random Forests: These algorithms naturally perform feature selection by considering the importance of features in splitting the data during tree construction.

Gradient Boosting Machines: These models can also provide feature importance scores, allowing for the selection of significant features based on their contributions to the model.

Symmetrical Uncertainty (SU) Based Feature Selection Method

Symmetrical Uncertainty (SU) [11] [12] is a feature selection method that quantifies the amount of information gained about one variable through another, balancing the measure of uncertainty in both variables. It is particularly useful in the context of categorical variables and has become a popular choice in various machine learning applications, including medical diagnostics, where the interpretation of results is crucial. SU provides a normalized measure that ranges from 0 to 1, facilitating the comparison of feature relevance across different datasets. Symmetrical Uncertainty is derived from the concept of mutual information, which measures the amount of information that knowing the value of one variable provides about another. SU is defined mathematically as follows: Symmetrical Uncertainty is derived from the concept of mutual information, which measures the amount of information that knowing the value of one variable provides about another. SU is defined mathematically as follows:

$$SU(X, Y) = \frac{2 \cdot I(X, Y)}{H(X) + H(Y)}$$





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Where $I(X, Y)$ is the mutual information between variables X and Y . $H(X)$ and $H(Y)$ are the entropy of variables X and Y , respectively. Mutual Information (I): This metric quantifies the reduction in uncertainty of one variable due to the knowledge of another. It is calculated as:

$$I(X, Y) = H(X) + H(Y) - H(X, Y)$$

Entropy (H): This measures the unpredictability or randomness of a variable. It is calculated using the probability distribution of the variable:

$$H(X) = - \sum_{x \in X} P(x) \log P(x)$$

Information Gain (IG) Based Feature Selection Method

Information Gain (IG) [13] [14] is a widely used metric in feature selection and decision tree algorithms that measures the effectiveness of a feature in reducing uncertainty about the target variable. It quantifies the amount of information that knowing the value of a feature provides about the target outcome. IG is particularly beneficial in classification tasks, including medical diagnoses, where understanding the relationship between features and outcomes is essential for developing predictive models. Information Gain is based on the concept of entropy, which measures the unpredictability or randomness of a variable. The IG of a feature is calculated by comparing the entropy of the target variable before and after the dataset is split by that feature. Mathematically, Information Gain is defined as:

$$IG(T, A) = H(T) - H(T|A)$$

Where $IG(T, A)$ is the information gain of feature A with respect to target variable T . $H(T)$ is the entropy of the target variable before the split. $H(T|A)$ is the conditional entropy of the target variable after the dataset is split based on feature A .

Entropy is calculated using the formula:

$$H(X) = - \sum_{x \in X} P(x) \log_2 P(x)$$

Where $P(x)$ is the probability of occurrence of value x .

Chi-Square Analysis Based Feature Selection Method

Chi-Square Analysis [15] [16] is a statistical method used to determine the independence between categorical variables. In the context of feature selection, the Chi-Square test assesses the relationship between each feature and the target variable to identify significant predictors. This method is particularly valuable in classification tasks, especially in medical datasets where categorical variables are prevalent. By evaluating how well each feature correlates with the target outcome, Chi-Square Analysis helps improve model performance and interpretability. The Chi-Square test compares the observed frequencies of occurrences in a contingency table with the expected frequencies under the assumption of independence. The Chi-Square statistic is calculated using the following formula:

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

χ^2 is the Chi-Square statistic, O_i is the observed frequency for category i , E_i is the expected frequency for the category i .

The expected frequency is calculated as:

$$E_i = \frac{(\text{row total} \times \text{column total})}{\text{grand total}}$$

The resulting Chi-Square statistic indicates how much the observed counts deviate from the expected counts. A higher Chi-Square value suggests a stronger association between the feature and the target variable.

Particle Swarm Optimization Algorithm

Particle Swarm Optimization (PSO) [17] [18] is a nature-inspired optimization algorithm developed by James Kennedy and Russell Eberhart in 1995. It is based on the social behavior of birds and fish, where individuals



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(particles) in a swarm collaborate to find optimal solutions within a search space. PSO is particularly effective for solving complex optimization problems, including those in machine learning, engineering design, and parameter tuning. Its simplicity, ease of implementation, and ability to converge to global optima make it a popular choice in various applications.

In PSO, each particle represents a potential solution in the search space and has two primary characteristics:

Position: The current location of the particle, representing a possible solution to the optimization problem.

Velocity: The rate of change of the particle's position, determining how the particle moves through the search space. Particles adjust their positions based on their own experience and that of their neighbors, balancing exploration (searching new areas) and exploitation (refining existing solutions). The PSO algorithm consists of the following key steps:

Initialization

Define the optimization problem and its objective function.

Initialize a swarm of particles with random positions and velocities within the defined search space.

Set parameters such as the number of particles, maximum iterations, and coefficients for cognitive and social components.

Fitness Evaluation

Evaluate the fitness of each particle by calculating the objective function's value at its current position.

Update Personal and Global Bests

For each particle, compare its fitness with its personal best (the best position it has encountered so far) and update it if the current position is better.

Determine the global best (the best position encountered by any particle in the swarm) based on fitness evaluations.

Update Velocity and Position

Adjust each particle's velocity using the following formula: $v_i = \omega \cdot v_i + C_1 \cdot r_1 \cdot (p_i - x_i) + C_2 \cdot r_2 \cdot (g - x_i)$ where v_i is the particle's current velocity, ω is the inertia weight that controls exploration versus exploitation, C_1 and C_2 are acceleration coefficients (typically set between 1.5 and 2), r_1 and r_2 are random numbers between 0 and 1, p_i is the personal best position of particle i , g is the global best position. Update the particle's position using: $x_i = x_i + v_i$

Iteration

Repeat steps 2 to 4 until a stopping criterion is met (e.g., maximum iterations or a satisfactory fitness level).

Output

Return the global best position and its corresponding fitness value as the optimal solution.

A Thrice Filtered Information Energy Optimization Based Feature Selection (TFIE-OFS) Method

The following are the step-by-step procedure for the proposed TFIE-OFS method.

Step 1: Data Preprocessing

Data Collection: Gather the dataset for the prediction or classification task (e.g., heart disease dataset).

Handle Missing Values: Impute missing values using techniques such as mean, median, or mode, or remove entries with significant missing data.

Feature Scaling & Encoding : Normalize numerical features using scaling techniques (e.g., Min-Max Scaling or Z-Score normalization). Convert categorical features into numerical format using label encoding or one-hot encoding.



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Split the Dataset: Divide the dataset into training and testing sets. The training set will be used for feature selection and model building, while the test set will be used to evaluate performance.

Step 2: Apply Three Filtering Methods: The feature selection begins by applying three filters independently, each of which evaluates the relevance of the features with respect to the target variable.

Step 2.1: Symmetrical Uncertainty (SU) Filter

Calculate Symmetrical Uncertainty: Compute the SU score for each feature by measuring the correlation between the feature and the target variable.

Rank Features: Rank the features based on their SU scores.

Select Top Features: Select the top k features with the highest SU scores. These are considered the most relevant to the target variable.

Step 2.2: Information Gain (IG) Filter

Calculate Information Gain: Compute the IG for each feature by quantifying the reduction in entropy when the feature is known.

Rank Features: Rank the features based on their IG scores, where higher IG values indicate greater importance.

Select Top Features: Select the top kkk features with the highest IG scores.

Step 2.3: Chi-Square Filter

Perform Chi-Square Test: For each feature, apply the Chi-Square test to determine its level of independence from the target variable.

Rank Features: Rank the features based on their Chi-Square values. Higher values suggest a stronger dependency between the feature and the target.

Select Top Features: Select the top k features with the highest Chi-Square values.

Step 3: Combine Results of the Three Filters

Step 3.1: Intersection of Feature Sets: Combine the results of the three filters (SU, IG, and Chi-Square) by taking the intersection of the top-ranked features from each method.

This ensures that only the most relevant features, as agreed upon by all three methods, are retained for further analysis.

The combined feature set is smaller and more focused on high-impact predictors.

Step 4: Particle Swarm Optimization (PSO) for Feature Selection

Once the filtered feature set is determined, PSO is used to further optimize the selection of features.

Step 4.1: Initialize PSO Algorithm

Swarm Initialization: Initialize a population (swarm) of particles. Each particle represents a potential subset of the selected features from Step 3.

Position & Velocity: Initialize the position and velocity of each particle randomly. The position represents a feature subset.



**Vanaja and Hari Ganesh****Step 4.2: Define Fitness Function**

Classification Performance: The fitness function evaluates how well the selected feature subset performs in classification. Use a machine learning model (e.g., Support Vector Machine, Decision Tree) to calculate performance metrics such as accuracy or F1-score.

Fitness Value: The fitness value for each particle is the classification accuracy (or any relevant performance metric) of the model using the particle's feature subset.

Step 4.3: Update Particle Velocity & Position

For each particle, update the velocity using the above mentioned formula.

Step 4.4: Evaluate Fitness of Each Particle

After updating the position, evaluate the fitness (classification performance) of the new feature subset for each particle.

Update Personal Best (p_i): If a particle's current fitness is better than its personal best, update its personal best.

Update Global Best (g): If any particle's current fitness is better than the global best, update the global best.

Step 4.5: Iterate Until Convergence

Repeat the velocity and position updates, and re-evaluate the fitness of particles for a predefined number of iterations or until convergence (when no further improvement is observed in the global best).

Step 5: Select Optimal Feature Subset**Step 5.1: Identify the Best Feature Subset**

Once PSO converges, the global best position (i.e., the best-performing feature subset) is selected as the optimal feature set.

Step 5.2: Train Final Model

Use the optimal feature subset to train the final classification model (e.g., on a Decision Tree, SVM, or any chosen model).

RESULT AND DISCUSSION**Performance Metrics**

The performance of the proposed Feature Selection method is evaluated with their existing feature selection methods like Genetic Algorithm, Artificial Bee Colony (ABC) Optimization, Whale Optimization Algorithm (WOA), and Cultural Algorithm (CA) using classification techniques like Artificial Neural Network (ANN), Support Vector Machine (SVM) and Random Forest (RF). The dataset used in this research work is considered from the Kaggle Repository [19] Table 1 depicts the performance metrics used to evaluate the performance of the proposed and existing feature selection methods. Table 2 depicts the number of features obtained by the Proposed and existing feature selection methods. From the table 2, it is clear that the proposed TFIE-OFS method gives less number of features than the existing feature selection methods. Table 2 compares the number of features selected by the existing feature selection methods (Symmetrical Uncertainty (SU), Information Gain (IG), Chi-Square (CS)) and the proposed Thrice Filtered Information Energy Optimization-based Feature Selection (TFIE-OFS) method. The proposed TFIE-OFS method selects a more refined set of features, emphasizing its efficiency in identifying the most relevant attributes for classification. The SU method selects a total of 9 features, including key attributes like "chol," "cp," and "exang.". The IG method also selects 7 features, but with variations such as the absence of "age" and "trestbps.". The CS method selects 7 features but includes a different set, emphasizing "old peak" and "trestbps.". The proposed TFIE-OFS method selects 6 features, streamlining the selection to the most critical attributes such as "cp," "ca," and "thal."



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Table 3 depicts the classification accuracy (in %) obtained by the Heart Disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets. Table 3 presents the classification accuracy (in %) of various classification techniques (ANN, RF, SVM) applied to the heart disease dataset after using different feature selection methods: Genetic Algorithm (GA), Artificial Bee Colony (ABC), Whale Optimization Algorithm (WOA), Crow Search Algorithm (CA), and the proposed TFIE-OFS method. The original dataset without feature selection provides the lowest classification accuracy across all classifiers: 48.32% (ANN), 43.97% (RF), and 42.86% (SVM), indicating the necessity of feature selection to improve performance. Among the existing feature selection methods, CA yields the highest accuracy: 72.59% (ANN), 71.67% (RF), and 69.78% (SVM). The proposed TFIE-OFS method achieves the highest classification accuracy across all classifiers, with 94.91% (ANN), 93.46% (RF), and 85.69% (SVM), showing a substantial improvement over the other methods. GA achieves respectable results but still lags behind TFIE-OFS, with accuracies of 70.84% (ANN), 69.34% (RF), and 67.43% (SVM). ABC and WOA produce similar but slightly lower accuracies, ranging between 55-59% for all classifiers.

Table 4 depicts the True Positive Rate (in %) obtained by the Heart Disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets. Table 4 presents the True Positive Rate (in %) of various classification techniques (ANN, RF, SVM) applied to the heart disease dataset after using different feature selection methods: Genetic Algorithm (GA), Artificial Bee Colony (ABC), Whale Optimization Algorithm (WOA), Crow Search Algorithm (CA), and the proposed TFIE-OFS method. The original dataset without feature selection results in the lowest True Positive Rate (TPR), with 52.76% (ANN), 51.26% (RF), and 46.35% (SVM), highlighting the need for feature selection to improve detection rates. Among the existing methods, CA achieves the highest TPR, with 83.19% (ANN), 82.3% (RF), and 69.24% (SVM). The proposed TFIE-OFS method significantly outperforms all other methods, achieving TPRs of 95.51% (ANN), 92.42% (RF), and 79.96% (SVM), indicating superior performance in correctly identifying positive cases. GA shows competitive results with TPRs of 74.45% (ANN), 73.05% (RF), and 71.16% (SVM), but still lags behind TFIE-OFS. ABC and WOA exhibit similar performance, with TPRs ranging from 59-63% across all classifiers, which is higher than the original dataset but lower than GA and CA.

Table 5 depicts the False Positive Rate (in %) obtained by the Heart Disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets. Table 5 presents the False Positive Rate (FPR in %) of various classification techniques (ANN, RF, SVM) applied to the heart disease dataset after using different feature selection methods: Genetic Algorithm (GA), Artificial Bee Colony (ABC), Whale Optimization Algorithm (WOA), Crow Search Algorithm (CA), and the proposed TFIE-OFS method. The original dataset shows the highest False Positive Rate across all classifiers, with 56.58% (ANN), 63.8% (RF), and 64.32% (SVM), highlighting its poor ability to minimize false positives without feature selection. Among the existing methods, CA achieves the lowest FPR, with 25.60% (ANN), 31.91% (RF), and 33.42% (SVM). The proposed TFIE-OFS method significantly outperforms all other methods, reducing the FPR to 5.72% (ANN), 5.36% (RF), and 13.36% (SVM), indicating a dramatic reduction in false positives and enhancing the accuracy of classification. GA performs moderately, reducing FPR to 32.87% (ANN), 35.31% (RF), and 36.22% (SVM), which is significantly better than the original dataset but higher than CA and TFIE-OFS. ABC and WOA have similar FPR values, ranging from 43-48%, which is better than the original dataset but worse than GA and CA.

Table 6 depicts the Precision (in %) obtained by the heart disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets. Table 6 presents the Precision (in %) obtained by various classification techniques (ANN, RF, SVM) applied to the heart disease dataset after using different feature selection methods: Genetic Algorithm (GA), Artificial Bee Colony (ABC), Whale Optimization Algorithm (WOA), Crow Search Algorithm (CA), and the proposed TFIE-OFS method. The original dataset yields the lowest precision across all classifiers: 51.60% (ANN), 47.71% (RF), and 46.53% (SVM), indicating high levels of false positives without feature selection. Among the existing feature selection methods, CA achieves the highest precision, with 80.17% (ANN), 73.20% (RF), and 72.83% (SVM). The proposed TFIE-OFS method dramatically improves precision across all classifiers, with the highest values: 95.53% (ANN), 94.32% (RF), and 82.65% (SVM), demonstrating its superior performance in accurately identifying positive instances. GA also delivers competitive precision results, with 73.52%



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(ANN), **70.60%** (RF), and **69.81%** (SVM), though it still falls short of CA and TFIE-OFS. ABC and WOA perform similarly, with precision values in the **60-63%** range, which is an improvement over the original dataset but not as effective as GA, CA, or TFIE-OFS.

Table 7 depicts the Specificity (in %) obtained by the heart disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets. Table 7 shows the Specificity (in %) of various classification techniques (ANN, RF, SVM) applied to the heart disease dataset after different feature selection methods: Genetic Algorithm (GA), Artificial Bee Colony (ABC), Whale Optimization Algorithm (WOA), Crow Search Algorithm (CA), and the proposed TFIE-OFS method. The original dataset exhibits the lowest Specificity across all classifiers: 43.42% (ANN), 36.2% (RF), and 35.68% (SVM), indicating poor performance in identifying true negatives without feature selection. Among the existing methods, CA provides the highest Specificity, with 74.4% (ANN), 68.09% (RF), and 66.58% (SVM), reflecting a notable improvement. The proposed TFIE-OFS method achieves the highest Specificity across all classifiers: 94.28% (ANN), 92.64% (RF), and 86.64% (SVM), showcasing its superior ability to correctly identify negative cases. GA also performs well, yielding Specificity values of 67.13% (ANN), 64.69% (RF), and 63.78% (SVM), but remains less effective than CA and TFIE-OFS. ABC and WOA show moderate improvements, with Specificity values in the 51-56% range, indicating some effectiveness but falling behind GA, CA, and TFIE-OFS.

Table 8 depicts the Miss Rate (in %) obtained by the Heart Disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets. Table 8 presents the Miss Rate (in %) obtained by various classification techniques (ANN, RF, SVM) when applied to the heart disease dataset processed using different feature selection methods: Genetic Algorithm (GA), Artificial Bee Colony (ABC), Whale Optimization Algorithm (WOA), Crow Search Algorithm (CA), and the proposed TFIE-OFS method. The original dataset produces the highest Miss Rates: 47.24% (ANN), 48.74% (RF), and 53.65% (SVM), indicating a high rate of misclassification without feature selection. GA reduces the Miss Rate significantly to 25.55% (ANN), 26.95% (RF), and 28.84% (SVM), though it is still not as effective as CA or the proposed TFIE-OFS method. ABC and WOA have moderate Miss Rates, ranging from 36.66% to 40.87%, showing a better performance than the original dataset but are less effective than GA, CA, or TFIE-OFS. CA achieves a substantial reduction in Miss Rate, especially for ANN and RF classifiers, with values of 16.81% (ANN) and 17.7% (RF). However, for SVM, the Miss Rate is relatively higher at 30.76%. The proposed TFIE-OFS method achieves the lowest Miss Rates: 4.49% (ANN), 7.58% (RF), and 20.04% (SVM), demonstrating its superior ability to minimize classification errors across all classifiers.

Table 9 depicts the False Discovery Rate (in %) obtained by the heart disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets. Table 9 presents the False Discovery Rate (FDR in %) obtained by applying various classification techniques (ANN, RF, SVM) to the heart disease dataset processed using different feature selection methods: Genetic Algorithm (GA), Artificial Bee Colony (ABC), Whale Optimization Algorithm (WOA), Crow Search Algorithm (CA), and the proposed TFIE-OFS method. The original dataset exhibits high False Discovery Rates, with values of 48.4% (ANN), 52.29% (RF), and 53.47% (SVM), indicating a substantial number of false positives when no feature selection is applied. The GA method leads to a noticeable reduction in FDR to 26.48% (ANN), 29.4% (RF), and 30.19% (SVM), demonstrating some effectiveness in improving classification accuracy compared to the original dataset. ABC and WOA achieve moderate reductions in FDR, with values ranging from 36.24% to 43.99%, reflecting a better performance than the original dataset but still higher than GA and CA. The CA method significantly lowers the FDR, achieving 19.83% (ANN), 26.8% (RF), and 27.17% (SVM), indicating its strong potential in minimizing false discoveries. The proposed TFIE-OFS method shows remarkable results, yielding the lowest False Discovery Rates of 4.47% (ANN), 5.68% (RF), and 17.35% (SVM), showcasing its effectiveness in correctly identifying true positives and significantly reducing false positives.





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CONCLUSION

The Thrice Filtered Information Energy Optimization Based Feature Selection (TFIE-OFS) method represents a significant advancement in feature selection techniques for classification and prediction tasks, particularly in high-dimensional datasets such as those used in heart disease diagnosis. By integrating three robust filtering methods—Symmetrical Uncertainty, Information Gain, and Chi-Square Analysis—TFIE-OFS effectively narrows down the feature space to include only the most relevant predictors. This multi-filtering approach ensures a comprehensive assessment of feature importance, leading to a more refined selection process. Furthermore, the incorporation of Particle Swarm Optimization (PSO) enhances the feature selection process by optimizing the subset of features based on their contribution to model performance. The results from the various evaluations of the Thrice Filtered Information Energy Optimization-based Feature Selection (TFIE-OFS) method indicate its significant efficacy in improving the performance of heart disease classification tasks. The proposed TFIE-OFS method consistently outperformed existing feature selection techniques across multiple metrics, demonstrating its ability to enhance classification accuracy, reduce false discovery rates, minimize miss rates, and maintain high specificity.

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Table 1: Performance Metrics used in this research work

Metrics	Equation
Accuracy	$TP+TN/TP+FN+TN+FP$
True Positive Rate (TPR) (Sensitivity or Recall)	$TP/TP+FN$
False Positive Rate (FPR)	$FP/FP+TN$
Precision	$TP/TP+FP$
True Negative Rate (Specificity)	$1- \text{False Positive Rate (FPR)}$
Miss Rate	$1- \text{True Positive Rate (TPR)}$
False Discovery Rate	$1- \text{Precision}$

Table 2: Number of Features obtained by the Existing and Proposed Feature Selection Methods

Feature Index	Number of Features selected by existing feature selection methods and proposed TFIE-OFS method			
	SU	IG	CS	TFIE-OFS
1	chol	cp	age	cp
2	cp	age	old peak	ca
3	exang	thal	trestbps	thal
4	ca	ca	cp	slope
5	slope	trestbps	ca	exang
6	old peak	exang	thal	chol
7	sex	slope	exang	
8	age		slope	
9	trestbps			

Table 3: Classification Accuracy (in %) obtained by the heart disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets

Feature Selection Methods	Classification Accuracy (in %) by Classification Techniques		
	ANN	RF	SVM
Original dataset	48.32	43.97	42.86
GA	70.84	69.34	67.43
ABC	59.73	58.43	56.32
WOA	58.64	57.34	55.43
CA	72.59	71.67	69.78
Proposed TFIE- OFS method	94.91	93.46	85.69





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Table 4: True Positive Rate (in %)obtained by the heart disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets

Feature Selection Methods	True Positive Rate (in %) by Classification Techniques		
	ANN	RF	SVM
Original dataset	52.76	51.26	46.35
GA	74.45	73.05	71.16
ABC	63.34	62.16	60.24
WOA	62.25	61.27	59.13
CA	83.19	82.3	69.24
Proposed TFIE- OFS method	95.51	92.42	79.96

Table 5: False Positive Rate (in %)obtained by the heart disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets

Feature Selection Methods	False Positive Rate (in %) by Classification Techniques		
	ANN	RF	SVM
Original dataset	56.58	63.8	64.32
GA	32.87	35.31	36.22
ABC	43.78	44.42	47.35
WOA	44.69	45.53	48.43
CA	25.60	31.91	33.42
Proposed TFIE- OFS method	5.72	5.36	13.36

Table 6: Precision (in %)obtained by the heart disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets

Feature Selection Methods	Precision(in %) by Classification Techniques		
	ANN	RF	SVM
Original dataset	51.60	47.71	46.53
GA	73.52	70.60	69.81
ABC	62.80	61.57	56.01
WOA	63.76	60.86	57.54
CA	80.17	73.20	72.83
Proposed TFIE- OFS method	95.53	94.32	82.65

Table 7: Specificity(in %)obtained by the heart disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets

Feature Selection Methods	Specificity (in %) by Classification Techniques		
	ANN	RF	SVM
Original dataset	43.42	36.2	35.68
GA	67.13	64.69	63.78
ABC	56.22	55.58	52.65
WOA	55.31	54.47	51.57
CA	74.4	68.09	66.58
Proposed TFIE- OFS method	94.28	92.64	86.64





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Table 8: Miss Rate (in %) obtained by the Heart Disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets

Feature Selection Methods	Miss Rate (in %) by Classification Techniques		
	ANN	RF	SVM
Original dataset	47.24	48.74	53.65
GA	25.55	26.95	28.84
ABC	36.66	37.84	39.76
WOA	37.75	38.73	40.87
CA	16.81	17.7	30.76
Proposed TFIE- OFS method	4.49	7.58	20.04

Table 9: False Discovery Rate (in %) obtained by the heart disease dataset using original dataset, GA, ABC, WOA, CA and proposed TFIE-OFS methods processed datasets

Feature Selection Methods	False Discovery Rate (in %) by Classification Techniques		
	ANN	RF	SVM
Original dataset	48.4	52.29	53.47
GA	26.48	29.4	30.19
ABC	37.2	38.43	43.99
WOA	36.24	39.14	42.46
CA	19.83	26.8	27.17
Proposed TFIE- OFS method	4.47	5.68	17.35





Cloud Forensics: A Comprehensive Review of Current Techniques and Emerging Trends

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ABSTRACT

As cloud computing continues to gain prominence, the need for effective forensic methodologies tailored to cloud environments has become increasingly critical. This literature review explores the integration of machine learning (ML) and deep learning (DL) techniques in cloud forensics, aiming to enhance the efficiency and effectiveness of digital investigations. The review highlights various applications of ML and DL algorithms in tasks such as data acquisition, anomaly detection, and evidence extraction, emphasizing their ability to process vast amounts of data generated in cloud environments. Key challenges, including data privacy concerns, the complexity of cloud architectures, and the need for real-time analysis, are also addressed. Furthermore, the review discusses the advantages of employing these advanced techniques over traditional forensic methods, showcasing case studies that demonstrate their successful implementation. By synthesizing current research, this review aims to provide a comprehensive understanding of how ML and DL can transform cloud forensic practices, paving the way for future innovations in the field.

Keywords: Cloud Computing, Machine learning, Deep Learning, Cloud Forensic, Traditional Forensic Methods





INTRODUCTION

The proliferation of cloud computing has revolutionized the way organizations manage, store, and analyze data. With its scalability, flexibility, and cost-effectiveness, cloud computing has become the backbone of modern information technology infrastructure. However, as organizations increasingly migrate to cloud environments, the need for robust forensic methodologies to investigate incidents involving cloud services has also grown. Traditional digital forensics techniques, originally designed for on-premises systems, often fall short in addressing the unique challenges posed by cloud architectures, such as data distribution, multi-tenancy, and dynamic resource allocation [1]. Digital forensics in cloud environments involves the collection, preservation, analysis, and presentation of digital evidence from cloud services. This process is inherently complex due to the virtualization of resources and the abstracted nature of cloud services. Consequently, the investigation of cloud-related incidents, such as data breaches, insider threats, and unauthorized access, necessitates advanced forensic approaches that can adapt to the evolving landscape of cloud computing [2].

In recent years, machine learning (ML) and deep learning (DL) have emerged as powerful tools in various domains, including cybersecurity and digital forensics. ML algorithms can analyze large datasets, identify patterns, and make predictions based on historical data, making them particularly suitable for forensic investigations where vast amounts of information need to be processed quickly and accurately. On the other hand, DL techniques, which leverage neural networks to model complex data patterns, have shown significant promise in tasks such as image and speech recognition, natural language processing, and anomaly detection [3]. The integration of ML and DL in cloud forensics presents a paradigm shift, enabling investigators to automate and enhance various stages of the forensic process. For instance, these technologies can facilitate the automated identification of malicious activities, streamline data acquisition processes, and improve the accuracy of evidence analysis. Moreover, ML and DL can assist forensic analysts in filtering through vast amounts of cloud data, allowing them to focus on critical evidence while minimizing manual effort [4].

Despite the potential benefits, the application of ML and DL in cloud forensics is not without challenges. Issues such as data privacy, compliance with legal frameworks, and the intricacies of cloud service provider architectures must be carefully considered. Additionally, the evolving nature of cyber threats necessitates continuous updates and training of ML and DL models to ensure their effectiveness in detecting and responding to new attack vectors [5]. This literature review aims to explore the current state of research on the application of ML and DL in cloud forensic environments. By analyzing existing studies, case examples, and emerging trends, this review seeks to provide a comprehensive understanding of how these advanced techniques can enhance cloud forensic practices. Furthermore, it will highlight the challenges and limitations associated with their implementation, paving the way for future research and innovations in the field.

Background Study Of Digital Forensic

Digital forensics, often referred to as computer forensics, is the practice of collecting, analyzing, and preserving digital evidence from electronic devices such as computers, smartphones, servers, and storage media to investigate and solve crimes or security incidents. The primary goal of digital forensics is to maintain the integrity of evidence while adhering to legal and procedural standards so that it can be used in both criminal and civil court proceedings. Over the years, digital forensics has evolved significantly in response to the increasing complexity of digital devices, networks, and the growing sophistication of cybercrimes [6]. The field covers a wide range of activities, including the recovery of deleted files, analysis of computer logs, detection of malware or malicious software, investigation of unauthorized access or data breaches, and reconstruction of digital actions taken by individuals or groups.



**Mahalakshmi and Subhashini****Historical Development of Digital Forensics**

Digital forensics traces its roots to the late 20th century, coinciding with the growth of computers and the internet. The term "computer forensics" emerged in the 1980s as computers became more widely used in business, education, and government sectors. The increasing reliance on computers and networked systems brought about new avenues for criminal activities, necessitating the development of specialized techniques for investigating such crimes [7]. In its early days, digital forensics primarily involved analyzing standalone computer systems, focusing on recovering data from hard drives and investigating cybercrimes such as hacking, fraud, and intellectual property theft. However, as digital devices and internet technologies evolved, so did the field of digital forensics. The expansion of mobile devices, cloud computing, social media, and the Internet of Things (IoT) has introduced new challenges and opportunities, leading to the development of various subfields of digital forensics.

Key Subfields of Digital Forensics

Digital forensics is now an umbrella term that covers several specialized subfields, each addressing specific types of digital devices, networks, or incidents [8]:

Computer Forensics: Focuses on investigating desktop and laptop computers. It involves analyzing file systems, memory, logs, and applications to recover evidence of criminal activities such as fraud, hacking, or insider threats.

Network Forensics: Involves the monitoring and analysis of network traffic and activities. It is crucial for investigating network intrusions, data breaches, distributed denial-of-service (DDoS) attacks, and unauthorized access to systems.

Mobile Device Forensics: Specializes in the extraction and analysis of data from smartphones, tablets, and other handheld devices. With the increasing use of mobile apps and services, mobile forensics plays a vital role in investigations related to social media, messaging apps, and location data.

Cloud Forensics: A newer branch that deals with the challenges of investigating incidents in cloud environments. Cloud forensics requires unique approaches for acquiring and analyzing data stored on remote servers and managed by third-party service providers.

Memory Forensics: Focuses on analyzing volatile data stored in computer memory (RAM). This subfield is particularly important for uncovering malware, rootkits, and other malicious activities that reside in memory but do not leave traces on the hard disk.

IoT Forensics: As the number of IoT devices increases, this subfield addresses the challenges of investigating incidents involving interconnected devices such as smart home systems, wearables, and industrial IoT sensors.

The Digital Forensic Process

The process of digital forensics is generally divided into several key phases that ensure the proper handling and analysis of digital evidence. These phases include [9]:

Identification: This phase involves identifying the digital devices or systems that may contain evidence relevant to the investigation. It also includes defining the scope of the investigation, determining the types of data to be collected, and understanding the potential sources of evidence.

Preservation: The preservation of digital evidence is critical to maintaining its integrity. This phase ensures that the data is not altered or corrupted during the investigation. It involves creating exact copies (forensic images) of the digital media for analysis, while the original data is securely stored to maintain its chain of custody.

Collection: In this phase, investigators gather relevant data from the identified devices or networks. This can involve copying hard drives, extracting data from cloud services, retrieving logs from network devices, and using specialized tools to access encrypted or hidden files.





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Analysis: This is the most time-consuming phase, where investigators examine the collected data for evidence of criminal or unauthorized activities. This phase may involve recovering deleted files, examining file metadata, identifying malware or suspicious software, and tracking user actions. The analysis must be performed methodically and documented thoroughly for accuracy and transparency.

Interpretation: The interpretation phase focuses on making sense of the analyzed data. It involves drawing conclusions based on the evidence and reconstructing events or timelines that explain how the crime or security incident occurred.

Reporting: Finally, the investigator compiles the findings into a formal report. This report must be clear, concise, and understandable to non-technical stakeholders, such as law enforcement, lawyers, or court officials. It must also adhere to legal standards so that the evidence can be presented in court if necessary.

Background Study Of Cloud Forensic

Cloud forensics is a specialized subfield of digital forensics that focuses on the investigation and analysis of digital evidence stored and processed in cloud computing environments. As organizations increasingly adopt cloud services to host their applications, store data, and leverage scalable infrastructure, the necessity for effective forensic methodologies tailored to these complex environments has become paramount [10].

Evolution of Cloud Forensics

The rise of cloud computing, characterized by on-demand access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications), has transformed how organizations manage data. While cloud computing offers numerous benefits, including cost efficiency, scalability, and flexibility, it also introduces unique challenges for forensic investigations. Initially, digital forensics techniques were designed for traditional IT environments, where data was localized and easier to manage. However, with the emergence of cloud computing in the early 2000s, investigators faced new hurdles due to the distributed nature of data across multiple servers and geographical locations. The challenges associated with investigating incidents in cloud environments prompted the development of cloud forensics as a distinct field.

Core Principles of Cloud Forensics

Cloud forensics operates under several guiding principles to ensure the integrity and reliability of the investigation process:

Data Ownership and Jurisdiction: Cloud environments often involve multiple stakeholders, including cloud service providers (CSPs), third-party vendors, and clients. Understanding data ownership and the legal jurisdiction in which data resides is crucial for forensic investigations, as these factors influence the accessibility and admissibility of evidence.

Data Preservation: In cloud forensics, preserving data integrity is critical. Investigators must create forensic copies of relevant cloud data without altering it. This often involves working closely with CSPs to ensure proper data preservation techniques are employed, especially when dealing with volatile data such as logs and ephemeral data.

Chain of Custody: Maintaining a proper chain of custody is essential to ensure the admissibility of digital evidence in legal proceedings. This involves documenting every step of the forensic process, from data acquisition to analysis, and ensuring that all actions taken are traceable and reproducible.

Comprehensive Data Acquisition: Cloud forensics requires a thorough understanding of cloud architecture and services. Investigators must identify all potential sources of evidence, including virtual machines, storage buckets, and application logs, to ensure comprehensive data acquisition.





LITERATURE REVIEW

Sachdeva, Shaweta, and Aleem Ali [11] Several distributed denial of service assaults, including the User Datagram Protocol Attack, Transmission Control Protocol Sync Attack, and Internet Control Message Protocol Attack, were taken into consideration for data classification in this research. With the advent of digital forensics, the explosion of network traffic and its variety on the Internet presented a new difficulty for attack detection. This document computes the maximum True Negative Rate, accuracy, and precision. We suggest a machine learning-based approach for attack classification in cloud networks that incorporates a digital forensics procedure. Our results show that our detection approach has outstanding True Negative Rate, accuracy, and precision. As a result, the deep learning-based fusion technique we have suggested for Digital Forensics performs admirably as a data classification detective. Kathane, Kavita Arun, and Viren Kumar Sharma [12] introduced an innovative framework that uses Deep Q-Network (DQN) for intelligent decision-making, Long Short-Term Memory (LSTM) based Graph Analysis for relational data processing, and Gated Recurrent Units (GRU) combined with Recurrent Neural Networks (RNN) for dynamic user profile activities. A special blend of adaptability, real-time processing activities, and profound contextual understandings is provided by this synergistic method. We show that, in a variety of scenarios, our framework increases the accuracy by 8.3%, recall by 4.9%, precision of attack event categorisation by 4.5%, and Area under the Curve (AUC) by 5.5%. These developments improve real-time threat identification and user-specific anomaly detection procedures while also greatly reducing false positives and false negatives. This research opens the door for a new breed of flexible, effective, and efficient cloud forensic systems, greatly enhancing the security posture of contemporary cloud computing environments by overcoming the drawbacks of previous approaches.

Senthil, P., and S. Selvakumar [13] presented a hybrid deep learning strategy for forensic investigation that is based on integrated multi-model data fusion (HDL-DFI). First, we focus on digital evidence gathering and management systems, which can be accomplished using an improved brain storm optimisation (IBSO) algorithm in conjunction with an integrated data fusion model. Here, we examine a variety of multimedia data—text, image, speech, physiological signals, and video—for the objective of providing proof. Then, in order to prevent duplicate and redundant data when gathering evidence, we introduce a recurrent multiplicative neurone with a deep neural network (RM-DNN). Next, we create a sentiment analysis multistage dynamic neural network (MDNN) to determine the sort of crime that has occurred and categorise the action on it. Finally, our suggested HDL-DFI model built with the standard benchmark database and its fallouts are compared to the state-of-the-art replicas (AUC) in terms of accuracy, precision, recall, F1-score, G-mean, and area under the curve. Savaridassan, P., and G. Maragatham [14] The goal of the Integrated Deep Auto-Encoder and Q-learning-based Deep Learning (IDEA-QLDL) Scheme is to maximise prediction accuracy while examining log data and dividing it into authentic and anomalous observations. It starts the acceptance/denial process based on ongoing analysis of highly applicable behavioural patterns for classification. When compared to the benchmarked schemes that were taken into consideration for inquiry, the findings of the proposed IDEA-QLDL Scheme demonstrated its superiority in enhancing the classification accuracy, precision, recall, and detection time.

Chitti, Praveen, K. Prabhushetty, and Shridhar Allagi [15] In the suggested approach, the authors use Discrete Cosine Transform (DCT) for feature extraction in the second iteration of the Convolution Neural Network machine learning model, and SVM in the first iteration for detecting the forged region. An average accuracy of 98% is achieved for all types of picture operations, including scaling, rotation, and augmentation, when the suggested model is tested on a Corel 10K dataset. Bhardwaj, Sonam, and Mayank Dave [16] A model for gathering and preserving crypto-evidence is put forth. The model is used to classify network traffic data as either harmful or non-malicious, detect malware attacks, and retain evidence. The gathered digital evidence is effectively preserved, and it is kept in protected mode (tamper-safe). Deep learning and machine learning classifiers are used to extract malware traffic meta-data. Numerous studies have demonstrated that while ensemble classifiers raise the likelihood of improved malware prediction analysis and real-time data flowing over a network, deep learning effectively helps the study of big data sets. The deep learning model proposed in this article is based on an ensemble classifier, and it can be used to



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investigate malicious packets, preserve evidence using the SHA-256 cryptosystem, learn from collected data, and maintain the evidence's availability when needed for forensic investigations involving malware attacks on networks.

Srilatha, Doddi, and N. Thillaiarasu [17] This article looks at how cloud resources are affected and suggests a practical intrusion detection system (IDS) called DDoSNet. This research study makes use of the CICIDS 2017 dataset to assess models. For feature selection, the intelligence technique of particle swarm optimisation (PSO) is used. To categorise the given data as benign or malicious, the deep neural network (DNN) model receives as input the optimum features. When evaluating the model, the accuracy rate, precision, recall, and F1-score metrics are taken into account. The experimental findings indicate 099.81% accuracy, 099.77% precision, 099.89% recall, and 099.83% F1 score. The system that is being shown performs better than traditional machine learning models. As such, this strategy instills great confidence in cloud service security. Sachdeva, Shaweta, and Aleem Ali [18] gave a thorough understanding of the issue at hand and suggested narrative remedies for the examination of current log analysis, TCP Sync Attack, UDP Attack, and ICMP Attack. Using a hybrid technique, digital forensics for attack detection in a cloud network environment might improve present computational complexity difficulties and apply cyber-forensic investigation (KNN, MLP) in a less complex system. Our suggested method works incredibly well for categorising the attack dataset.

Hemdan, Ezz El-Din, and D. H. Manjaiah [19] offered a productive Cloud Forensics Investigation Model (CFIM) for prompt, forensically sound cloud criminal investigation. In addition, the suggested solution incorporates the idea of Forensic as a Service (FaaS), which offers a host of advantages for doing digital forensics via the use of Forensic Server in the cloud. The findings of the inquiry demonstrated that the suggested approach can effectively support digital investigators in their quest to look into cybercrimes in the cloud. Manzoor, Nosheen, *et al* [20] Digital crime is investigated through the use of digital forensics. The most deadly cyberattacks on the internet are those that use botnets. It is difficult to conduct a digital forensic analysis into botnet attacks. The capacity of attackers to plan increasingly intricate attacks with Botnets is expanding. To counter such attacks, the digital forensics must be strengthened. In network forensics, machine learning is crucial for quickly and effectively identifying various types of botnet attacks. Machine learning techniques were applied to various network forensic methods. Botnet assaults are not only detected but also prevented using machine learning algorithms. This paper presents a summary of the various botnet assaults and digital forensic investigative approaches to counter the botnet attacks. To present the evidence in a court of law, forensic investigation of Botnet detection requires a consistent framework. In the article, many network forensic approaches have also been described.

Lv, Zhihan, and Ranran Lou [21] In order to strengthen cloud storage security, the current work investigates edge-fog-cloud computing storage security. The study uses pre-processed data from an industrial intelligent manufacturing machine. Perception data for machine production comprises both data transmission and data storage. Additionally, digital twins technology is utilised to create a digital twin in the real world that simulates the online data-driven behaviour of machine production, along with the perceptual data of machine manufacturing. 3Dmax builds and saves the digital twins model. At last, deep learning technology is presented as a means of preventing network intrusion. Both external and internal assaults by cloud data providers can affect cloud databases. In order to guarantee that the database contains ciphertext data and executes data queries directly, the homomorphic encryption algorithm and secure multi-party computing are implemented. Adikari, Samriddha, Jinfeng Su, and Kamini Simi Bajaj [22] This study's objective is to use secondary research to examine recent findings on deep learning-based network forensic optimisation methods. The main conclusions are that deep learning technology outperforms state-of-the-art techniques in identifying assaults during data communication in Internet of Things systems. The main parts of the systems that the researchers proposed were found in this study, arranged in a table, and categorised using a methodology that demonstrated the ability of deep learning technology to recognise attacks in Internet of Things devices.

Shakeel, P. Mohamed, *et al* [23] suggested using the blockchain-assisted shared audit framework (BSAF) to examine IoT platform digital forensic data. In order to identify the origin or source of data scavenging attacks in virtualised



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resources (VR), a recommended methodology was created. Blockchain technology is used in the suggested architecture to manage access logs and controls. Using cross-validation and logistic regression (LR) machine learning, adversary event detection consistency is examined in access log data. Thapaliya, Suman, and Pawan Kumar Sharma [24] A model that takes feature fusion into account is described for identifying cyberattacks. The Fractional Gravitational Search Algorithm (FGSA) is used to route data towards Base Station (BS). Cybercrime detection is carried out at BS, where data is divided using enhanced fuzzy c-means clustering (FCM) while taking the MapReduce model into consideration. While the reduction handles cybercrime detection, the mapper uses mutual information and the Deep Quantum Neural Network (DQNN) to fuse features. The Deep Belief Network (DBN) based on Fractional Mayfly Shepherd Optimisation (FrMSO) is designed to describe the digital examination to detect and track the behaviours of attacks in the Internet of Things. The suggested FrMSO algorithm, which was created by combining the Shuffled Shepherd Optimisation Algorithm (SSOA), the Mayfly Optimisation Algorithm (MA), and the Fractional Calculus (FC), trains the DBN in this instance.

Nazar, Nidhin, *et al* [25] Massive volumes of information are frequently available in the field of cyber forensics, perhaps more than in other forensics specialities. The difficulties and innovations associated with applying deep learning to cyber forensics are essentially the same as in any other field where artificial intelligence is utilised to address problems that are vital to an individual or, more often than not, an organisation. Initially, in order to combine Deep Learning with Cyber Forensics—that is, after an incident—it must first be taught in Cyber Security—more precisely, Cyber Defense—that is, before an incident. This concept makes a lot of sense. In this work, deep learning models are compared to the human brain, which is the most complex structure in the known universe. These models are, after all, founded on and inspired by the human brain. This study suggests ways that Deep Learning models could benefit the field of Cyber Security, particularly for the IR teams, and looks for current solutions on how to apply a Deep Learning model in the domains of Cyber Forensics. Barik, Kousik, *et al* [26] The study intends to examine numerous problems that arise during the course of the investigation as well as the various stages of digital forensic techniques. The study also focusses on the careful examination of several digital forensic instrument types. The process entails constructing, defending any scene, conducting a thorough examination, communicating effectively, and identifying. It also entails identifying all of the regulations for regulating proof as well as the prospects for digital inquiry. This article discusses the methods and resources that can be used to look into digital crime. Among the topics covered are desktop forensic tools, live forensic tools, operating system forensic tools, and email forensic tools.

Ahmad, Ayaz, *et al.* [27] provided research that might be utilised to develop plans for developing standards, guidelines, and technological research to minimise problems that can't be resolved by using the tools and techniques available today. This chapter covers a number of subjects, including cloud computing, cybercrimes, digital forensics, and cloud forensics. The fundamentals and overview of cloud computing, digital forensics, cybercrimes, difficulties, and prospects in the field of cloud forensics are also explored. A review of the literature on related work to digital forensics techniques in the cloud computing environment is included, along with the state of the art in the cloud forensic area. Rajeev, Aishwarya, and P. Raviraj [28] explored a wide range of forensic analysis disciplines, including as audio, video, and network forensics. Many methods are employed in this study to accomplish various forms of forensic analysis, including Random Forest, Multilayer Perceptron (MLP), and Convolutional Recurrent Neural Networks (CRNN). Additionally, image fusion is employed, which can extract features from the source photos and provide more information than a single image. With an accuracy of 98.02 percent, this study concluded that the random forest offers the best outcomes for network forensic investigation. The paper attempts to give a comprehensive overview of the substantial amount of work that has been done in the subject of video source authentication in recent years through a review of existing techniques and machine learning algorithms.

Ramesh, S., *et al* [29] Deep Learning (DL) models offer automated malware classification, spam, phishing, and intrusion detection as well as the extraction of optimal values from network data. By making judgements based on evidential weights, the DL-based cyber forensic investigation engine makes it easier to preserve, analyse, and understand evidence. The purpose of this chapter is to highlight the developments and breakthroughs in deep



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learning for digital and cyber forensics Arshad, M. Zeeshan, et al[30] This paper's primary goal is to create a framework that security can use to conduct forensic investigation on IoT devices with limited resources. In this study, we have suggested a system that uses a node to node (N2N) architecture to automatically do forensic analysis and detect the many types of assaults carried out on the endpoint (IoT device). In order to identify various attack types, this suggested solution also combines a variety of forensic tools with machine learning techniques. It addresses the issue of recovering evidence from the compromised endpoint by using a third-party log server. We have used the security onion (forensic server) to analyse the logs in order to ascertain the type and scope of the assault. Furthermore, this framework is capable of employing various machine learning methods to automatically identify assaults.

Research Gaps

Despite its importance, cloud forensics faces numerous challenges:

Complexity of Cloud Architectures: Cloud environments are often highly complex, comprising various service models (IaaS, PaaS, SaaS) and deployment models (public, private, hybrid). Investigators must navigate this complexity to locate and analyze relevant evidence effectively.

Multi-tenancy Issues: In cloud environments, multiple clients often share the same infrastructure, which raises concerns about data isolation and privacy. Investigators must ensure that they do not inadvertently access data belonging to other clients, which could lead to legal and ethical issues.

Dynamic and Ephemeral Data: Cloud environments can generate vast amounts of dynamic data, such as logs and temporary files, that may be deleted or overwritten quickly. This impermanence complicates the data collection process, as investigators must act swiftly to capture evidence before it is lost.

Limited Access to CSP Infrastructure: Investigators often have limited access to the underlying infrastructure of CSPs, making it challenging to perform in-depth forensic analysis. Collaboration with CSPs is essential to obtain necessary data, but legal and operational hurdles may impede timely access.

Legal and Regulatory Compliance: The legal landscape surrounding cloud forensics is complex, with varying regulations across jurisdictions. Investigators must remain compliant with local laws and international regulations regarding data privacy and security.

Volume and Variety of Data: The sheer volume of data generated by modern digital devices and systems presents a substantial challenge. Digital forensics experts must sift through terabytes or even petabytes of data to locate relevant evidence. The variety of data formats and storage systems also complicates the process.

Encryption and Privacy Issues: Encryption technologies, while essential for securing personal and corporate data, can impede forensic investigations. Decrypting encrypted files often requires specialized tools and expertise, and in some cases, may be impossible without access to encryption keys.

Future Research Direction

As digital technologies continue to evolve, so too does the field of digital forensics. One of the most significant trends in recent years is the growing use of artificial intelligence (AI) and machine learning (ML) in forensic investigations. These technologies offer the potential to automate certain aspects of the forensic process, such as the identification of anomalies or the classification of evidence. Additionally, the increasing use of blockchain technologies in data storage and transactions has introduced new opportunities and challenges for digital forensics, particularly in the areas of fraud detection and secure record-keeping. Furthermore, as cloud computing and IoT devices continue to expand, forensic investigators will need to adapt to the distributed and decentralized nature of these systems. New tools and



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methodologies will be required to effectively investigate incidents in environments where data is stored across multiple platforms and geographies.

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Enhancing Quality of Service in Cloud Computing: A Comprehensive Review of Techniques and Challenges

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ABSTRACT

The rapid growth of cloud computing has revolutionized data storage, application hosting, and resource management, making it a cornerstone of modern digital infrastructure. However, the adoption of cloud services introduces critical challenges related to performance optimization, Quality of Service (QoS), and security. This literature review aims to explore various strategies that have been proposed to improve cloud computing performance while maintaining high QoS standards and robust security measures. The review delves into techniques such as dynamic resource allocation, virtualization, load balancing, and traffic management to enhance system efficiency and scalability. It also examines encryption protocols, authentication mechanisms, and intrusion detection systems aimed at fortifying cloud security. By analyzing current research, this review highlights the trade-offs between performance and security, offering insights into how emerging technologies such as machine learning, blockchain, and edge computing are being integrated to strike a balance. The findings provide a comprehensive understanding of the existing frameworks and future directions for optimizing cloud performance without compromising on QoS and security requirements.

Keywords: Cloud Security, Quality of Service, Security





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INTRODUCTION

Cloud computing has become an integral part of modern information technology infrastructures, enabling organizations and individuals to access and manage data, applications, and services over the internet. Its promise of on-demand resource availability, scalability, cost efficiency, and flexibility has driven widespread adoption across various industries, including healthcare, finance, education, and entertainment. However, as reliance on cloud computing increases, so do the challenges related to ensuring high levels of performance, Quality of Service (QoS), and security. Performance in cloud computing refers to the ability of cloud systems to provide users with fast, efficient, and reliable access to resources while handling large-scale workloads. This aspect is crucial in cloud environments where unpredictable spikes in demand can strain resources. To mitigate these issues, cloud service providers (CSPs) deploy performance enhancement techniques such as dynamic resource allocation, load balancing, and virtualization, which aim to maximize resource utilization and maintain optimal system throughput. However, maintaining high performance often comes at the expense of other critical factors, such as QoS and security [1] [2].

Quality of Service (QoS) represents the overall service quality experienced by end-users, encompassing elements such as availability, latency, bandwidth, and error rates. It is essential in maintaining user satisfaction and ensuring seamless operation for businesses relying on cloud services. The dynamic and distributed nature of cloud environments complicates QoS management, requiring sophisticated algorithms for resource allocation, traffic management, and real-time monitoring. Ensuring consistent QoS across geographically dispersed data centers, varying network conditions, and diverse workloads remains a complex challenge for CSPs [3]. At the same time, security in cloud computing is paramount, given the sensitivity of the data and applications hosted in these environments. Organizations entrust CSPs with confidential data, making cloud infrastructures attractive targets for cyberattacks. Cloud security encompasses a wide range of concerns, including data protection, user authentication, network security, and compliance with privacy regulations. Techniques such as encryption, intrusion detection, access control, and multi-factor authentication are employed to safeguard cloud environments. However, achieving high levels of security often involves overhead that can negatively impact performance, creating a trade-off between security measures and the efficiency of cloud operations [4] [5].

In this context, the interplay between performance, QoS, and security becomes a critical area of concern for researchers and practitioners alike. Improving performance while maintaining a robust QoS and ensuring high security levels presents a unique set of challenges. For instance, adding security measures such as encryption can lead to increased computational load, thus reducing performance. Similarly, prioritizing performance optimization might lead to gaps in security or compromise on QoS aspects like latency or service availability. This literature review seeks to explore the existing body of research that addresses these interconnected challenges in cloud computing. By examining state-of-the-art methodologies and technologies, including machine learning-based optimization techniques, blockchain for decentralized security, and edge computing for distributed workloads, the review will highlight approaches aimed at enhancing cloud performance without compromising QoS or security. It will also identify key trends and future directions in the field, particularly the integration of emerging technologies to balance performance, QoS, and security requirements in cloud environments.

Background Study of Cloud Security

Cloud computing has become a cornerstone of modern digital infrastructure, enabling organizations to deploy, store, and process data with unprecedented scalability, flexibility, and cost efficiency. However, as cloud adoption grows, so does the complexity of ensuring the security of these vast, distributed systems. Cloud security encompasses a broad range of technologies, protocols, and policies designed to protect data, applications, and infrastructure from a wide array of threats. The unique characteristics of cloud environments—such as multi-tenancy, on-demand resource provisioning, and remote access—create significant challenges for securing data integrity, confidentiality, and availability.



**Jeya and Baby Deepa****The Evolution of Cloud Security**

Cloud security evolved alongside the development of cloud computing technologies. Initially, concerns about security were among the biggest barriers to cloud adoption, with enterprises hesitant to entrust sensitive data to third-party service providers. Over time, cloud providers invested heavily in developing security mechanisms that address both traditional IT security concerns and the novel risks introduced by cloud infrastructures [6] [7]. Traditional data centers operated within a single organizational boundary, where physical and network access controls could be tightly managed. In contrast, cloud environments are shared, decentralized, and accessible over the internet, raising new challenges in protecting against insider threats, external attacks, and accidental data leaks. To mitigate these risks, cloud service providers (CSPs) have implemented a range of security measures, such as encryption, identity management, access controls, and auditing tools. However, securing cloud environments is not solely the responsibility of CSPs; it requires a collaborative effort between providers and users, each responsible for different layers of the security model.

Shared Responsibility Model

One of the foundational concepts in cloud security is the Shared Responsibility Model. In this model, cloud service providers and customers share the responsibility of securing data and infrastructure, though the scope of responsibility varies based on the cloud service model used—Infrastructure as a Service (IaaS), Platform as a Service (PaaS), or Software as a Service (SaaS). IaaS: In an IaaS model, the cloud provider manages the physical data center, servers, and network, while the customer is responsible for securing the operating system, applications, and data. This model provides the greatest control for the user but also demands the most comprehensive security management from the customer's side.

PaaS: In PaaS, the provider also manages the underlying infrastructure and platform (such as operating systems and middleware), leaving customers responsible mainly for securing their applications and data. Security responsibilities here are somewhat reduced for customers but still involve considerable attention to data protection and application security. SaaS: In a SaaS model, the cloud provider handles nearly everything—network, servers, applications, and data storage—while the customer is generally responsible for securing their access credentials and managing user permissions. SaaS users are at the mercy of the provider's security measures, making it critical for customers to carefully evaluate their provider's security practices.

Key Cloud Security Threats

As cloud adoption grows, so does the landscape of threats targeting cloud environments. Some of the most prominent security threats include:

Data Breaches: Data breaches remain one of the most significant threats to cloud security. Multi-tenant cloud environments, where data from multiple customers resides on shared infrastructure, increase the risk of unauthorized access. Breaches can occur due to poor configuration, weak access controls, or vulnerabilities in cloud services. High-profile data breaches, such as the Capital One incident in 2019, underscore the risks posed by misconfigurations in cloud infrastructure [8].

Data Loss: Data loss can occur for a variety of reasons, including accidental deletion, hardware failures, software bugs, and malicious attacks (such as ransomware). In a cloud context, ensuring data redundancy and backup procedures are critical for minimizing the risk of permanent data loss. While replication across multiple data centers can help mitigate this risk, it also requires careful management to ensure consistency and data integrity.

Insider Threats: Cloud environments are particularly vulnerable to insider threats due to the vast number of users with varying levels of access. Employees or administrators of cloud providers, as well as users within an organization, may intentionally or unintentionally misuse their access, leading to data breaches or service disruptions. Insider threats can be mitigated by strong access controls, logging, and continuous monitoring.



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Denial of Service (DoS) Attacks: Distributed Denial of Service (DDoS) attacks, which aim to overwhelm cloud services with traffic, can render services unavailable to legitimate users. Cloud providers offer DDoS mitigation tools, such as traffic filtering and load balancing, but large-scale attacks can still cause significant disruptions, especially for smaller providers [9].

Insecure APIs: Application Programming Interfaces (APIs) are widely used in cloud environments to enable integration and automation. However, insecure APIs—those lacking proper authentication, encryption, or access controls—can expose cloud systems to cyberattacks. Ensuring the security of APIs is a critical aspect of cloud security, requiring regular auditing and testing for vulnerabilities.

Account Hijacking: Weak or stolen credentials remain a common attack vector in cloud security. Once attackers gain access to cloud accounts, they can manipulate data, steal sensitive information, or perform malicious activities under the guise of legitimate users. Multifactor authentication (MFA), encryption, and strict access controls are essential defenses against account hijacking.

Background Study of the Data Replication Methodologies

Cloud computing offers numerous advantages such as scalability, flexibility, and cost efficiency. However, ensuring **Quality of Service (QoS)** in a cloud computing environment remains one of the most significant challenges faced by both Cloud Service Providers (CSPs) and users. QoS in cloud computing refers to the overall performance of the cloud system, which includes metrics such as **availability, reliability, latency, bandwidth, and error rates**. A high QoS guarantees that users can access services consistently and reliably, without interruptions or delays. Achieving and maintaining this quality is complex due to the dynamic, distributed, and resource-shared nature of cloud environments[10]. This background study explores the major concepts, existing challenges, and solutions in improving QoS in cloud systems.

QoS Metrics in Cloud Computing

To better understand how QoS can be improved, it is essential to identify the key performance indicators (KPIs) or metrics that define the quality of service in cloud computing environments:

Availability: The percentage of time a cloud service is accessible and operational. High availability ensures that services are always accessible to users.

Latency: The time taken to respond to a user request. Lower latency is crucial in performance-sensitive applications such as real-time data processing.

Reliability: The ability of a system to function without failure over a specific time period. High reliability is critical for long-running processes and transactions.

Throughput: The rate at which data is processed and transferred. Ensuring high throughput is necessary for data-intensive applications.

Scalability: The ability to handle increasing workloads by allocating more resources. A scalable system adapts efficiently to demand fluctuations.

Security and Privacy: Although security and privacy are often separate domains, their management affects QoS. Any breaches in security can degrade service quality and customer trust.





LITERATURE REVIEW

Wang, Jinjiang, *et al*[11] proposed strategy, termed LBVMP, seeks to establish a novel framework comprising a balanced flat surface of a physical machine (PM) regarding CPU, RAM, and bandwidth (BW), alongside another proportional flat surface representing the remaining resource capacity of the targeted PM divided by the requested resources (CPU, RAM, and BW) of a virtual machine (VM). Subsequently, LBVMP computes the distance between two plots to assess VM allocation solutions. Xu, Heyang, *et al.* [12] Examined the issue of fault tolerance-aware VM scheduling and articulated it as a multi-objective optimisation model incorporating various QoS constraints. The proposed model aims to minimise customers' overall spending while simultaneously maximising the successful execution rate of their enterprises. A greedy-based best fit decreasing (GBFD) algorithm is then designed to resolve the proposed optimisation model. The GBFD method employs a cost efficiency factor defined by the characteristics of CNs to select an appropriate CN for each VM request. Comprehensive experiments are performed to validate the practicality of the suggested models and algorithms using both real-world CDC cluster datasets and simulated data. Tamilarasu, P., and G. Singaravel [13] An Improved Coati Optimisation Algorithm-based Task Scheduling (ICOATS) is proposed to mitigate prolonged scheduling durations, excessive costs, and increased stress on Virtual Machines (VMs) in cloud computing environments. This suggested ICOATS constructs a model for work distribution and scheduling based on the variables of virtual machines, cost, and time. It also incorporated a multi-objective fitness function aimed for minimising makespan while simultaneously maximising resource utilisation efficiency. It established a potential strategy for each coati about the task scheduling process, which assists in identifying the appropriate assignment of incoming work to virtual machines (VMs). The proposal addresses premature convergence by integrating an exploitation method that enhances local search potential through a well-balanced trade-off between exploration and exploitation.

Rajak, Ranjit, *et al* [14] Task scheduling, characterised by dependencies between activities, is executed by resource allocation via Directed Acyclic Graph (DAG) scheduling. DAG is a crucial scheduling method because to its extensive applicability in various domains, including environmental technology, resource management, and energy optimisation. NP-completeness is a prominent issue, prompting the proposal of numerous models in the literature to address it. Nonetheless, the emergence of Quality of Service (QoS)-aware services in the CCE platform has become a significant and prevalent method for delivering computing resources, presenting a fresh essential challenge. The primary objective of this work is to formulate an innovative Directed Acyclic Graph (DAG) scheduling model to enhance the Quality of Service (QoS) parameters in the CCE platform, which can be validated using comprehensive simulation techniques.

Sharma, Minakshi, Rajneesh Kumar, and Anurag Jain [15] The proposed approach is an expansion of the previously suggested quality of service (QoS)-enabled join minimum loaded queue (JMLQ). The suggested methodology has been evaluated using the CloudSim simulator, and the findings indicate that it outperforms QoS-enabled JMLQ and its variants within the cloud context. Monika, and Om Prakash Sangwan [16] Utilised an innovative backpropagation-based Adaptive Dynamic Programming parameter tuning strategy, incorporating two fundamental prediction methods, to create a self-adaptive intelligent system that offers automatic parameter tuning capabilities for both techniques. To assess the suggested methodology, we conducted a simulation using a real QoS dataset, and the experimental findings indicate superior prediction accuracy relative to conventional methods.

Pakhrudin, Nor Syazwani Mohd, Murizah Kassim, and Azlina Idris [17] The aim of this research is to enhance the efficacy of the existing RR approach for action scheduling in the cloud by reducing the average waiting, turnaround, and response times. The CloudAnalyst tool was employed to refine the RR approach by adjusting parameter values to optimise for high accuracy and cheap cost. The results indicate that the total minimum and maximum response times achieved are 36.69 ms and 650.30 ms, respectively, for a duration of 300 minutes of RR. The expense for the virtual machines (VMs) ranges from \$0.50 to \$3.00. The duration of usage correlates positively with the expense of data transfer. This research is crucial for enhancing communication and the quality of interactions among groups.



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Malla, Parvaz Ahmad, and Sophiya Sheikh [18] Cloud computing systems are recognised as significant consumers of energy resources globally. Moreover, power consumption has emerged as a critical factor since the majority of cloud computing systems rely on conventional nonrenewable energy sources. To render data centres environmentally sustainable, it is essential to implement optimal strategies to minimise energy usage and their detrimental impact on the environment. The primary purpose of this research is to examine several ways for constructing and sustaining an energy-efficient cloud. The paper will thoroughly examine several energy-efficient resource provisioning techniques and present a graphical comparison analysis of Quality of Service (QoS) metrics in cloud computing. Furthermore, the current study delineates the domains requiring enhancement to augment the energy efficiency of cloud computing systems.

Katkar, Alok, *et al* [19] This abstract provides an overview of current achievements in the automated assessment of quality of service in cloud computing systems. Cloud computing architectures provide substantial flexibility and scalability to clients. The total performance of a cloud platform is significantly affected by the quality of service. The quality of service is generally determined by outstanding criteria, including response time, availability, throughput, security, and others. Intelligent approaches have gained increased prominence for enhancing the quality of service monitoring and measuring. These tactics employ Artificial Intelligence (AI) and machine learning (ML) technologies to detect anomalies. Automated measures are implemented to guarantee the maintenance of superior service quality. Tabassum, Nazia, and C. R. K. Reddy [20] VANET and Cloud Computing will significantly contribute to the advancement of efficient technology for autonomous driving, vehicle control, and intelligent systems in the near future. Cloud computing is a centralised paradigm that fails to adequately manage numerous Quality of Service (QoS) parameters, such as latency, throughput, and bandwidth optimisation. Fog Computing (FC) is established in VANETs to address the constraints of Cloud Computing (CC). The IoV-CC must tackle issues related to security and privacy. Consequently, the security protocols employed in conventional VANET and CC must be revised for IoV-CC, necessitating the development of a new secure algorithm to ensure secure communication between FOG and cloud nodes. Innovating QoS in VANET for IoV-CC faces considerable challenges related to data dissemination and security. This project aims to investigate the data distribution and security acceptability of the Internet of Vehicles (IoV) in relation to centralised and decentralised computer systems.

Arunkumar, J. R. [21] The computer resources of cloud service providers are reassigned dynamically based on demand, with their infrastructure, platform, software, and other resources shared among various corporate and private clients. The continuous rise of cloud computing subscribers utilising shared resources has heightened concerns regarding cloud security. This review article delineates present cloud security challenges and practices, while proposing several creative solutions aimed at enhancing cloud computing security in future domains. Agarwal, Rajesh, and Sanjay Dhingra [22] This research aims to identify the determinants of cloud service quality and evaluate the influence of service quality on customer satisfaction and loyalty. A study with 419 cloud experts/users was executed in India utilising a structured questionnaire based on the Likert scale. The participants were cloud professionals and users utilising the services of the five leading cloud service providers in India. Research hypotheses were evaluated by partial least squares structural equation modelling. The research indicated that agility, service assurance, dependability, scalability, security, service responsiveness, and usability all positively and significantly influence total cloud service quality. The study demonstrated a partly mediating impact of customer satisfaction between service quality and customer loyalty. Service quality exhibits a favourable and strong correlation with customer loyalty and customer satisfaction.

Pawar, Ankush Balaram, Shashikant U. Ghumbre, and Rashmi M. Jogdand [23] This work aims to create and construct a paradigm for authentication and data security in cloud computing. This technique comprises six distinct units: cloud server, data owner, cloud user, inspection authority, attribute authority, and central certified authority. The devised privacy preservation system has multiple stages: setup phase, key creation phase, authentication phase, and data exchange phase. The setup step is initially conducted by the owner, who provides the security attributes, while the key creation stage produces the system master key and the public parameter. Subsequently, the authentication process is conducted to ascertain the security measures of the information system. The data is



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ultimately decrypted at the data sharing phase to facilitate data exchange and ensure privacy for confidential information. Furthermore, dynamic splicing is employed, alongside security mechanisms including hashing, Elliptic Curve Cryptography (ECC), Data Encryption Standard-3 (3DES), interpolation, polynomial kernel, and XOR, to safeguard sensitive data. Kirubakaran, S. Stewart, *et al* [24] Formulated a Privacy-Preserved Data Security Approach (PP-DSA) to provide data security and integrity for outsourced data in a Cloud Environment. This work ensures privacy preservation through the Efficient Authentication Technique (EAT), which use the Group Signature method in conjunction with a Third-Party Auditor (TPA). The auditor's responsibility is to safeguard data and ensure the integrity of shared information. Furthermore, the Cloud Service Provider (CSP) and Data User (DU) may also act as the perpetrators that must be addressed by the EAT. The primary aim of this effort is to improve cloud security and thus boost Quality of Service (QoS).

Sindjoug, Miguel Landry Foko, Mthulisi Velepini, and Clémentin Tayou Djamegni [25] Mobile Edge Computing (MEC) relocates computing and storage resources from cloud data centres to edge data centres, positioning them nearer to end-user devices to minimise end-to-end latency in request processing. Nonetheless, MEC is susceptible to security, data privacy, and authentication issues that impact the end-user Quality of Experience (QoE). It is essential to address these difficulties to prevent a subpar user experience resulting from inadequate security or data privacy. This research proposes a hybrid cryptographic system that integrates symmetric and asymmetric cryptographic methods to enhance data security, privacy, and user authentication in a MEC-based network. Guo, Zixuan, and Xuejun Yu [26] utilised the QoS (Quality of Service) of cloud services as the foundational data, derive the subjective weights of these services through AHP hierarchical analysis, ascertain the objective weights via the entropy weighting method, and calculate the recommendation degree for each service through weighting. Concurrently, they evaluate the trustworthiness of cloud services using the TOPSIS decision method, ultimately proposing the development of a cloud service trustworthiness metric model. This methodology mitigates the impact of user evaluation subjectivity on the trustworthiness assessment of cloud services by offering an objective and efficient trustworthiness metric. This study examines the processing of QoS data, the classification of metrics, and the application of the entropy weight approach to get the objective weights of the relevant metrics for cloud services.

Kaliyanandi, Maharajan, *et al* [27] developed a comprehensive strategy for load balancing in cloud computing that incorporates security measures. The Quantum-Based Security Framework has been developed, and the load is equilibrated by fuzzy logic. The primary security policies are effectively evaluated, and service is provided according to the user's specified requirements. The Security Framework devised a technique for cloud data storage by generating check bits in lieu of keys, enabling users to access their data upon verification of the check bits. Only the user may utilise the services and load balancing if the check bits produced by the user and the cloud service provider are same. Mirrored copies are created to mitigate the risk of data loss from failures or outages. This security technique enables us to achieve a high level of security. Liu, Xiaofei [28] The proposed methodology introduces a novel blended technique known as the Integrated Aquila Optimiser (IAO), which combines the traditional Aquila Optimiser (AO) with the Particle Swarm Optimisation (PSO) algorithm. The primary aim of this hybridisation is to address the deficiencies encountered by both AO and PSO algorithms. These algorithms are prone to becoming ensnared in local optima and exhibit restricted solution diversity. The suggested method introduces an innovative transition mechanism that enables appropriate changes between the search operators, assuring ongoing enhancements in the solutions. The transition method enables the algorithm to alternate between AO and PSO when either becomes stagnant or when solution variety diminishes. This adaptability improves the overall performance and efficacy of the hybrid method. The suggested IAO approach undergoes comprehensive testing via experiments done on the Cloudsim simulation platform.

Materwala, H., L. Ismail, and H. S. Hassanein [29] Introduced an innovative Artificial Intelligence QoS-SLA-aware adaptive genetic algorithm (QoS-SLA-AGA) to enhance application execution time for multi-request offloading in a heterogeneous edge-cloud computing environment, accounting for the effects of overlapping multi-request processing and variable vehicle speed. The suggested genetic algorithm incorporates an adjustable penalty function to accommodate the SLA constraints related to latency, processing time, deadlines, CPU, and memory needs.





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Numerical investigations and analyses juxtapose our QoS-SLA-AGA with baseline genetic-based, meta-heuristic Particle Swarm Optimisation (PSO), random offloading, All Edge Computing (AEC), and All Cloud Computing (ACC) methodologies. Ali, Munwar, *et al* [30] Proposed a viable method to tackle these concerns with a novel service paradigm termed Confidentiality-based Classification-as-a-Service (C2aaS), which executes data processing by dynamically categorising data depending on its security level in anticipation of cloud storage. Our suggested service model demonstrates superior security for confidential data and effectively mitigates cloud system overloading compared to existing ways.

Research Gap

There are several inherent challenges in ensuring a high QoS in cloud environments due to their architecture and operational nature:

Dynamic Resource Allocation: Cloud environments operate on shared infrastructure, and resource contention can degrade QoS. As users' demands fluctuate, CSPs must allocate computing, storage, and network resources dynamically to ensure consistent performance. Poor resource allocation algorithms can lead to underutilization or resource overloading, both of which negatively affect QoS.

Geographically Distributed Data Centers: Cloud data centers are often distributed across different regions to minimize latency and ensure redundancy. However, geographic distribution introduces the complexity of managing network latency, data replication, and consistency across diverse locations. Ensuring uniform QoS in such scenarios is challenging, especially for global users.

Fault Tolerance and Failover: Faults in hardware, software, or network components can lead to service outages or reduced performance. High fault tolerance mechanisms are required to maintain QoS during failures. Failover strategies must be seamless and fast, ensuring no degradation in service during resource or network failures.

Multi-Tenancy and Resource Sharing: In a cloud environment, resources are shared among multiple tenants (users). While this leads to efficient resource utilization, it also introduces the risk of "noisy neighbors," where the actions of one tenant can negatively affect the performance of others. For example, a tenant running a heavy workload may consume more bandwidth or CPU resources, causing delays for other tenants.

Future Research Direction

Given these challenges, researchers and cloud service providers have proposed various strategies to improve QoS in cloud computing environments.

Dynamic Resource Allocation and Auto-Scaling: Dynamic resource allocation is one of the most effective strategies to ensure QoS. Cloud systems use **auto-scaling** mechanisms that dynamically allocate or deallocate resources based on real-time demand. By leveraging machine learning and predictive analytics, CSPs can forecast usage patterns and allocate resources more efficiently, preventing both resource underutilization and overloading.

Load Balancing Techniques: Load balancing is crucial for distributing workloads evenly across cloud servers. This helps in avoiding overloading specific servers, reducing response times, and maintaining high availability. Different algorithms are used to implement load balancing in cloud environments:

Round Robin: Distributes requests to all servers in a circular fashion.

Least Connections: Sends requests to the server with the fewest active connections, thereby preventing overload.

Dynamic Load Balancing: Uses real-time performance metrics to allocate resources based on current loads.

Service Level Agreements (SLAs): Service Level Agreements (SLAs) are contracts between CSPs and customers, outlining the expected QoS levels, including availability, response time, and performance guarantees. SLAs serve as a



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framework for managing user expectations and hold CSPs accountable for performance and QoS failures. CSPs use SLAs to define specific thresholds, penalties, and compensations for non-compliance, incentivizing the maintenance of QoS.

Traffic Management and Network Optimization: Managing network traffic efficiently is essential to improving QoS in cloud systems. Network congestion or inefficient routing can lead to higher latencies and reduced throughput, negatively impacting performance. Advanced traffic management techniques, including Software-Defined Networking (SDN) and Network Function Virtualization (NFV), allow CSPs to dynamically manage network resources, optimize routing, and reduce latency.

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Machine Learning Classifications for Automatic Sentiment Analysis on Twitter

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ABSTRACT

The number of algorithms that can decipher the tone of social media posts has skyrocketed in the past several years. Regarding the airing of views and opinions in virtual and social media arenas, common thinking is antiquated. These expressions can describe a lot of different feelings and moods. Emotion and sentiment analysis encompass a wide range of methodologies. In favour of studying the positivity or negativity of these utterances, most research disregard the feelings they represent. To find out what these utterances really mean, this study goes beyond sentiment analysis. This work demonstrates that a hybrid rule-based technique may be used to produce an entirely annotated dataset for five emotions: angry, afraid, pleased, sorrowful, and devastated. The proposed approach used all 45,000 of our English-language tweets that had the keywords "COVID-19 and India" in this study's dataset. Support Vector Machine, Stochastic Gradient Boosting, Naive Bayes, Logistic Regression, Random Forest, and Logistic Regression were some of the machine learning classifiers used for sentiment and emotion classification. It has been found that the Support Vector Machine outperformed the other classification methods when we compared them.

Keywords: "COVID-19, Random Forest, machine learning, technique, dataset.





INTRODUCTION

The rise of microblogging in the last several years has greatly increased the accessibility of text that contains emotions. Microblogs' limited character limit has inspired new emotions and prompted people to communicate their ordinary thoughts in real-time. These are not the only textual sources; there are also blogs, social media, emails, and product reviews. In today's Internet-driven society, social media sites are the ideal places to air your grievances. People use several forms of media, including text, images, audio, and video, to express themselves. A vast volume of unstructured and unshaped content is posted on the Internet every second as a result of the overwhelming nature of text communication through social media. In order to comprehend human psychology, it is necessary to quickly examine newly generated data; sentiment analysis, which detects textual polarity, can assist. It processes the data and generates an opinion, be it positive, negative, or neutral, on anything (a person, a brand, a movie, an event, etc.). Sentiment analysis refers to the act of classifying the emotions conveyed in the source material.

In the case of a pandemic, social media sites like Facebook, Twitter, YouTube, etc., play an essential role. Fast and easy, millions of individuals all around the globe can share their thoughts on any number of issues using Twitter. Due to the public nature of this data, Twitter has become a major subject of research. Anyone can view a user's profile and reply to their tweets. Tweets provide a wealth of sentiment data on people's views on a variety of topics. Consequently, we developed an autonomous machine learning sentiment analysis model to determine customer sentiment. Because sentiment analysis isn't always accurate, we need emotion analysis, which can dependably determine how someone is feeling. For the most part, earlier studies on text classification concentrated on sentiment analysis, which assigns positive or negative labels to data, and the vast majority of these datasets were in English. Although neutral sentiments were included in certain studies, analyzing emotions rather than sentiments provides a better understanding of the data. Although there can be no more than two dimensions to a sentiment classification, we use the word "multi-dimensional" to further characterize emotions in this research. English has been the principal target language for the majority of models and tools. Even people for whom English is not a first language often write in English for publications.

Even among academics for whom English is not a first language, the majority use it for both study and writing purposes. Using English and data related to "COVID-19 and India" as our primary examples, we focus on annotation projection as a simple way to generate high-quality English datasets. All things considered, 45,000 English-language tweets concerning "COVID-19 and India" were utilized in order to investigate these mixed rules. This article goes into detail on text classification analysis, sentiment and emotion identification using machine learning, and more. Findings from applicable previous studies on emotion and sentiment analysis are compiled in Section 2 of this work. The methods proposed for assessing the mood and emotion in tweets are discussed in Section 3. Classifiers for machine learning, metrics for performance, techniques for extracting features, annotations for data, text preprocessing, and dataset collection are all components. Section 4 gives the results of the study on feelings and sentiments, and Section 5 concludes the whole endeavor.

REVIEW LITERATURE

Presented the six primary emotion types: sad, angry, disgusted, afraid, and happy. He laid out his major argument in regard to the suggested fundamental emotions. It was proposed a method for generic emotional responses based on psychological observations. With the inclusion of "anticipation" and "trust" in his list of basic emotion categories, Ekman increased the number of his categories from six to eight. Analyzed and rated existing text sentiment analytics and sentiment detection techniques. Also discussed were the problems that arose during the processes. A supervised machine learning system for emotion classification was developed and evaluated. Online and offline classification were the two primary functions it combined. In order to categorize emotions while working offline, a model-generating system named "Emotex" was created. Creating a two-stage framework named "EmotexStream" to categorize the emotion tracking of real-time tweets was necessary for the challenge. Over 90% of the emotions in the



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text messages were accurately categorized by the created algorithms, according to their tests. Classified Twitter user sentiment using both supervised and unsupervised algorithms. Making and using a vocabulary was essential for the classification process.

The model's score was determined by use of a Google search engine. Various datasets were subjected to sentiment identification using ML algorithms. Classification at the sentence level based on POS and unigram presence was shown to be the most accurate when additional variables were considered. Examined tweets for tone and emotional content. We collected all the tweets and responses that were subject-specific. Aside from user information, sentiments, emotions, etc., the collection also included text from Twitter. Sentiment and emotion detection in tweets were accomplished using the dataset. A number of user- and tweet-centric attributes formed the basis for the predicted user replies and influence scores. Finally, the latter data was utilized to provide suggestions for users, both generic and personalized, based on their behavior on Twitter. Gather tweets that displayed at least one of the seven main emotions. The 42,000 tweets that comprised the collection fairly reflected all of the human emotions. A vocabulary of over 40,000 words was built from this dataset; each phrase was linked to a weighted vector that represented a particular mood. After cleaning the tweets, we put different sentiment detection systems to the test.

Both lexically-centered and supervised ML-centered categorization were utilized in these methods. An ensemble technique, which utilized several multi-class classifiers trained using the unigram features of the lexicon, was used to finish the evaluation. After comparing the ensemble technique to other methods on both existing datasets and the one created for this study, the results showed that it performed the best. Ensemble classifier uses decision trees, k-nearest neighbors, and '1500' multilayer perceptron. Regardless of the text's regularity or irregularity, it could steadily and properly differentiate between different moods. The basic classifier's parameters were fine-tuned using Tree-structured Parzen Estimator. The 'three' datasets utilized to train the method were ISEAR, OANC, and CrowdFlower, and they involved both regular and irregular phrases. With a detection accuracy of 88.59% for irregular sentences and 99.49% for regular ones, the ensemble classifier proved to be the most effective. The normalizing function introduces a new way to determine tone. Their approach was more precise than the standard sum and mean function. Using the BERT model to analyze the tenor of Twitter data. Tweet locations and mentions of India are the two main pieces of information gathered. During the height of the pandemic, when fear seized people all across the globe, the tweets were compiled. An enormous quantity of anti-COVID-19 sentiment is seen in the sample.

A fully annotated dataset was constructed using eight commonly experienced emotions. In order to determine the intended tone of the text, they developed an algorithm that took the emoji into account. Discovered more about the COVID-19 pandemic's impact on people's physiological well-being through an analysis of worldwide Twitter data. Based on the emojis employed in the expressions, the study identified eight distinct emotional states. Familiarize yourself with the literature on textual emotion recognition, focusing on studies that analyze both overt and covert displays of emotion. The most effective methods are those that combine learning with hybridization and make use of conventional text representation, as demonstrated by the outcomes. Factors that impacted the efficiency of the proposed systems were also highlighted in the poll, including natural language processing tasks, part-of-speech tagging, and parsing. We created a system that can predict and identify emotions in text. Machine learning techniques that were considered for the classification included Decision Tree, k-Nearest Neighbor, Multinomial Naïve Bayes, and Vector support machine. At its core, the paradigm was based on the six core emotions.

METHODOLOGY

Every single tweet in this study is part of a Twitter corpus that we have annotated with fundamental emotions like angry, sad, joyous, and devastated. The corpus was annotated using a combined rule-based method that made use of Natural Language Processing tools. The suggested method will train an artificial classifier to identify attitudes and emotions expressed in tweets. Logistic Regression, Stochastic Gradient Boosting, Naïve Bayes, Support Vector





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Machine, Forest Random, and Logistic Regression were among the machine learning classifiers used to categorize the tweets based on the proposed emotions. We used distinctness, evoke, f1-score, and exactness as metrics to assess the classifiers on this corpus. The process of using machine learning classifiers to analyze sentiment and emotion on Twitter is illustrated in Figure 1. The steps of the process are these:

- Twitter Information Gathering
- Data Preprocessing
- Emotion and Sentiment Data Annotation
- Annotating Data for Emotions and Sentiment
- Evaluating Public Opinion
- Analyzing Emotions
- Assessment of Work Performance

Tweets Data Collection

With the help of Academic Research Access, we created a Twitter developer account to collect the required data. A Python-coded application might be registered with this account. The script is written in Python and the Tweepy module, which implements the Twitter API V2, is used to download data. If you want your data collected from Twitter, make sure all the tweets with the phrase "COVID-19 and India" are in English and don't have any retweets. We reduced the dataset by deleting tweets that contained responses, quotations, or retweets so that we could obtain an accurate prediction. The application retrieves the tweets in "JSON" object format, which includes the columns "id," "created_at," "author_id," "lang," and "text" for possible subsequent processing. Gathering Information, the vast majority of datasets found in the real world contain some combination of unclear, noisy, or missing data. Results from data mining operations performed on such disorderly and unexpected data would be inadequate. Data preparation is the only way to get good data. Accordingly, the "Noise" from the Tweets can be eliminated by modifying the raw data according to the preprocessing processes outlined below. The preprocessing entails the following steps:

- Each and every one of the tweets' words were lowercased.
- Removed all digits and punctuation.
- Deleted any and all links, HTML, and URLs from the text.
- Deleted every single emoji from the given text data.
- Edited the text to remove all hashtags.
- A greater variety of abbreviations, acronyms, and shortened words were used.
- A list of stop words provided by NLTK was used to tidy up the text.
- Added fewer gaps to ensure accurate sentence processing.
- Tokenization, which divides a larger piece of text into smaller pieces called tokens, was employed.
- Words were removed from the phrase word for word.
- To simplify the tweet, the procedure of lemmatization is applied to each word.
- The panda library is used to save the pre-processed dataset in a separate dataset, protecting the original downloaded dataset from any potential damage.

Annotating Data on Emotions and Sentiment

Annotation includes analysis of the collected tweets using the NLTK toolkit. The Python software adds sentiment and emotion annotations to tweets. The script assigns a "Positive" or "Negative" attitude to the tweet based on its tone and subjective content. Following the completion of pre-processing, the algorithm employs lemmatization to ascertain the sentiment associated with each word in the tweet. Anger, fear, joy, grief, and broken heart are all examples of such emotions. The two datasets are now ready for further processing.

Annotated Dataset Feature Extraction

Feature extraction refers to the process of converting data into characteristics that can be used in a machine learning model. Numbers are the most common input for machine learning algorithms. Since ML models can't comprehend human language, NLP relies on vectorization. Tokenization, or vectorization, is the process of transforming a list of





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messages or tweets into a matrix of vectors. The Bag of Words tool now maps the text or word into numerical vectors. Count Vectorizer and FT-FID can be used to extract these features. Count vectorizer is an easy way to get features out of a document by just counting how many times a word or token appears. A method for assigning relative importance to words or phrases inside a text or corpus is known as Frequency Term-Frequency Inverse text (FT-FID). In this study, we employ FT-FID as a feature extraction method; FT stands for the number of times a phrase or word appears in a tweet, and FID is the weight of the words calculated from their frequency. Due to the fact that the length of each tweet varies, it is possible for a term to occur many times in the dataset. Thus, the following is the formula for FT-FID:

FT=frequency of a word's occurrence in a text

word count of the paper

FID = word count of the paper

The quantity of papers that include the phrase

FTFID=FT*FID

Sentiment Analysis

Sentiment analysis is a subfield of Natural Language Processing that allows for the extraction of feelings, opinions, reviews, and thoughts from text, audio, video, and social media data. The tweets are categorized as favorable or negative based on sentiment analysis. The sentiment of tweets from our downloaded dataset is examined in this research using Frequency Term-Frequency Inverse Document (FT-FID) and five machine learning classifiers. Then, we evaluate these classifiers' performance using metrics like exactness, evoke, f1-score, and distinctness. We have created sentiment analysis that takes the tweets as input and uses them to measure the subjectivity and polarity of each message. Making use of the Python Textblob package—a wrapper for implementing thewe ran sentiment analysis on the Twitter corpus. Textblob is a great resource for learning the ropes of Natural Language Processing. Each tweet is assigned a subjective and polarity rating using Textblob. The sentiment subjectivity scale encompassed the whole spectrum, from 0 (no sentiment) to 1 (strong negative sentiment). A score between -1 and 1 was used to determine the polarity of each tweet based on its terms. Feelings of negativity are indicated by numbers between -1 and 0, while positive emotions are indicated by scores between 0 and 1.

Classification of Emotions

The process of organizing sentences or documents into a predefined structure is called classification. Separate from one another, rule-based and machine learning-based classification methods are available. Here, we classify tweets according to the emotions they convey using five ML classifiers: angry, scared, happy, sad, and devastated.

Support Vector Machine Classifier

In order to find the best separating hyper-plane with the widest margin to both sides, vector support machine—the most successful binary classifier primarily searches. The objective is to find a hypothesis that ensures the lowest conceivable true error. An exhaustive description of the operation of the SVM classifier is given in Figure 2 below. It is possible to define the decision boundary, also known as the hyperplane, using the SVM method. Figure 2 shows support vectors, which are the blue and green points, and the margin, which is the distance between the hyperplanes and the support vectors. The optimum hyperplane is the one that maximizes the margin, which is the purpose of SVM.

Bayes Naïve

Naïve Bayes is a fundamental machine learning classification approach that is based on Bayes' Theorem. The Naïve Bayes classifier is a fast, accurate, and dependable method that achieves high accuracy on large datasets. Historically, Naïve Bayes classifiers have mostly been used for text classification and analysis. The Naïve Bayes can be described by two words: "Naïve" and "Bayes ". Consequently, Bayes' theorem is applicable:

$$P(X|Y) = \frac{P(X|Y)P(Y)}{P(X)}$$





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the posterior probability of hypothesis X , given the observed event Y , is denoted as $P(X|Y)$. If a hypothesis is correct, then the likelihood probability, denoted as $P(Y|X)$, is high. The prior probability, $P(X)$, is the likelihood of the hypothesis before looking at the evidence, and the marginal probability, $P(Y)$, is the likelihood of the evidence after looking at it. Rational Regression When it comes to supervised machine learning algorithms, logistic regression is among the most popular and user-friendly options. We use logistic regression when our target variable is clear. Logistic Regression is a kind of predictive analysis that uses the idea of probability to make predictions about the future, such as whether the output value will be true or false, zero or one, etc. There are three ways to classify LR: binomial, multinomial, and ordinal. The function of X is predicted by a logistic regression model as $P(Y=1)$. Classification challenges involving LR include cancer cell identification, diabetes prediction, cancer detection, and many more.

Forest unstructured Among the many machine learning algorithms used to solve classification and regression problems, forest random is by far the most effective. The classifier Forest Random uses a random collection of training data to construct a set of decision trees called the Forest Random. The test object's ultimate class will be determined by the majority voting of various decision trees. The combination of several decision trees lowers the noise and improves the accuracy of the outputs. The forest random approach for machine learning is illustrated in picture 4 below. How profitable is a random improvement? The Stochastic Gradient Boosting method has proved successful in solving numerous sparse ML issues. Natural language processing and text classification are just two examples. Stochastic Gradient Descent offers many advantages, including being efficient and easy to utilize. A linear SVM -like SGD Classifier's decision boundary is shown in Figure 5. The SGD classifier uses two arrays, X and Y , just like its forerunners. X contains training samples with n features and n samples. The form of Y is n _samples, and it contains the goal values for the training samples. In each iteration, SGD finds the gradient of the function for a single instance instead of the gradient of the cost function overall.

Evaluation of Results We have calculated the success rate of the classifiers using the f1 score, exactness, distinctness, and evoke as indicators of information retrieval. Provides a rough approximation of the distinctness:

$$\text{Distinctness} = \frac{TP}{(TP+FP)}$$

Where TP is the total number of sentences correctly classified to a category, and FP is the total number of sentences incorrectly classified to a category.

$$\text{evoke} = \frac{TP}{(TP+FN)}$$

Where FN is the number of sentences that were not classified at all and TN is the numbers of sentences marked as being in a particular category and were not.

$$\text{F1-score} = \frac{\text{Distinctness} \times \text{evoke} \times 2}{(\text{Distinctness} + \text{evoke})}$$

The exactness is evaluated as in :

$$\text{Exactness} = \frac{TP+TN}{(TP+TN+FN+FP)}$$

RESULTS

Results for sentiment and emotion categorization using Twitter data using the proposed machine learning model are showcased. For this analysis, we put the proposed model through its paces in Python using our Twitter dataset. A number of classification metrics were employed to evaluate the proposed model, including evoke, distinctness, f1-score, and exactness. The research shows that while some tweets on "COVID-19 and India" are hostile, the vast majority are positive. Table 1 details the results of the performance measures used by the sentiment-based classifiers. When comparing the two methods, the SVM algorithm yields the weighting scheme's highest exactness value and the NB technique the lowest. Tables 2-6 provide the classifiers' results for bitterness, Afraid, delight, sorrow, and heartbroken, along with their exactness, distinctness, evoke, and f1-scores. According to the results, out of all the





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expressed emotions, "bitterness" was the most accurately captured. The proposed Machine Learning Model was able to validate more precise emotion classification in the Twitter data when used with the FT-FID weighting method.

CONCLUSION

This study aimed to examine the participants' emotional and mental experiences during the COVID-19 pandemic in India. This project builds a dataset that can show people's thinking for a specific domain so that Twitter data can be used for emotional prediction. In the proposed model, we analyzed the feelings and emotions using a variety of machine learning approaches. Classifiers trained with the proposed term weighting scheme (FT-FID) achieve accuracy levels greater than 85% when it comes to sentiment analysis. When it came to emotional analysis, the SVM classifier got the best results for the proposed emotions, with an approximate accuracy of 95%. In light of the current COVID-19 pandemic, it is more important than ever to monitor and control people's emotional and physical well-being. We grounded our model on worldwide tweets on "COVID-19 and India" since that's where the majority of individuals expressed their anger throughout the pandemic. How resistant are humans to the coronavirus can be uncovered by examining these facts. One way to make this work better is to use ML architectures that can detect and analyze sentiment and emotional classification in text data automatically.

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Table1: The precision with which a machine learning classifier can identify tweet tone

CLASSIFIER	METRICS				
	Sentiment	Exactness	Distinctness	evoke	F1-Score
VSM	P+	0.87	0.97	0.98	0.99
	N-		0.83	0.84	0.85
NB	P+	0.97	0.77	0.78	0.79
	N-		0.99	0.98	0.97
RF	P+	0.92	0.93	0.95	0.96
	N-		0.88	0.89	0.9
LR	P+	0.91	0.94	0.95	0.96
	N-		0.87	0.88	0.89
SGB	P+	0.81	0.91	0.93	0.95
	N-		0.89	0.91	0.92

Table 2 Results of naïve bayes classifier for emotions

Emotions	Exactness	Distinctness	evoke	F1Score
Joyfulness	0.97	0.98	0.92	0.97
Bitterness	0.98	0.98	0.93	0.94
Astonished	0.98	0.98	0.94	0.98
Heartbroken	0.96	0.96	0.94	0.98
Afraid	0.96	0.94	0.95	0.96





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Table 3 A vector-support machine classifier's results for emotion classification

Emotions	Exactness	Distinctness	evoke	F1Score
joyfulness	0.95	0	0	0
Bitterness	0.88	0	0	0
Astonished	0.63	0.1	0.1	0
Heartbroken	0.63	0.1	0.1	0.1
Afraid	0.69	0.71	2	0.87

Table 4 - Results from a logistic regression classifier that takes emotions into account

Emotions	Exactness	Distinctness	evoke	F1Score
Joyfulness	0.95	0.98	0.74	0.83
Bitterness	0.96	0.8	0.68	0.77
Astonished	0.95	0.97	0.86	0.94
Heartbroken	0.92	0.98	0.88	0.86
Afraid	0.89	0.87	0.98	0.84

Table 5 - Forest random results for emotions

Emotions	Exactness	Distinctness	evoke	F1Score
Joyfulness	0.78	0	0	0
Bitterness	0.86	0	0	0
Astonished	0.59	0	0	0
Heartbroken	0.59	0	0	0
Afraid	0.67	0.69	2	0.85

Table 6- A boost gradient classifier's emotional outcome

Emotions	Exactness	Distinctness	evoke	F1Score
Joyfulness	0.76	0	0	0
Bitterness	0.86	0	0	0
Astonished	0.79	0	0	0
Heartbroken	0.89	0	0	0
Afraid	0.63	0.65	1	0.85

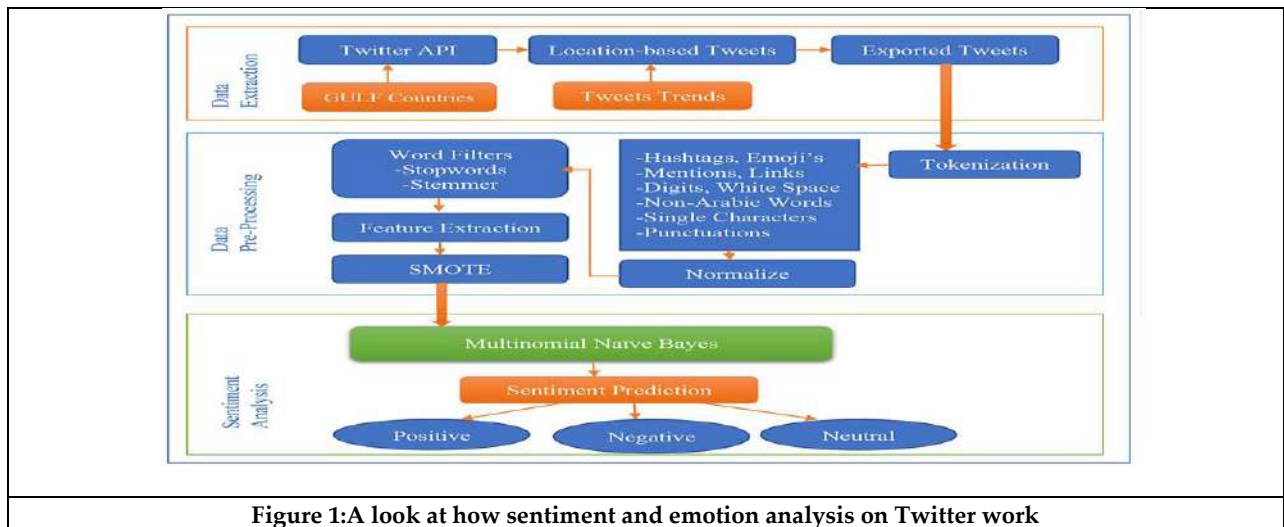


Figure 1: A look at how sentiment and emotion analysis on Twitter work





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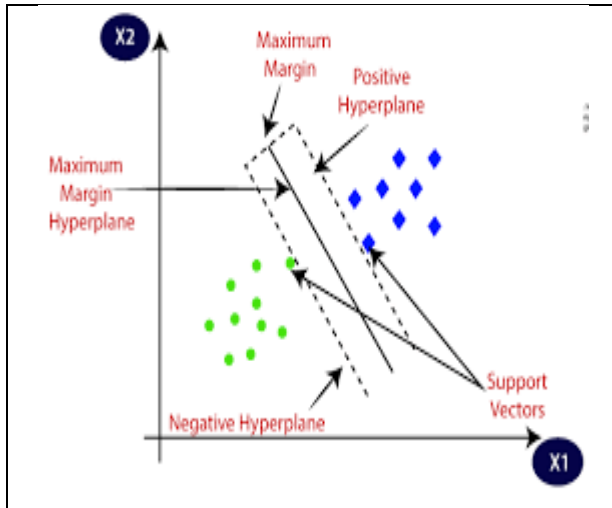


Figure 2: Algorithm for machine learning with vector assistance

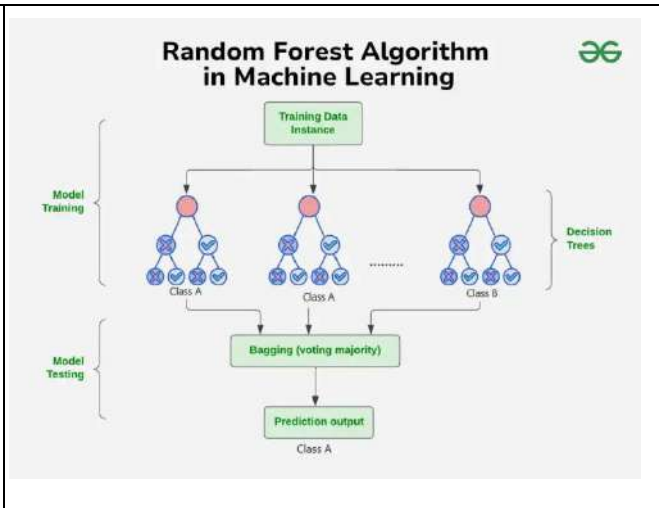


Figure 3: Mathematical Foundations of the Forest Random Algorithm

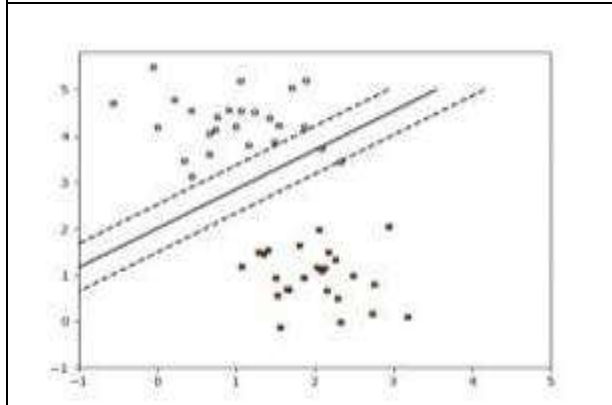


Figure 4 The machine learning algorithm known as Stochastic Boost gradient



Figure 5: Assessment of several emotion analysis classifiers according to their accuracy

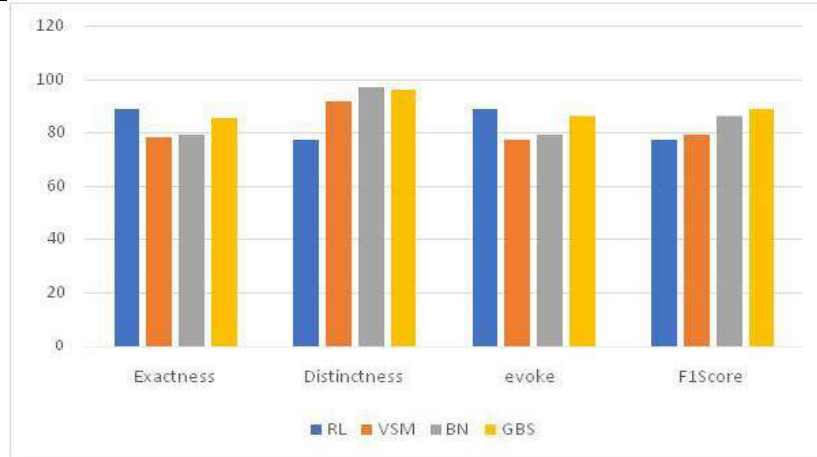


Figure 6 Assessment of several emotion analysis classifiers according to their accuracy





The Evolution of Massive Open Online Courses (MOOCs): A Comprehensive Literature Review on Their Impact and Effectiveness in Higher Education

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ABSTRACT

This literature review examines the impact of awareness and perception of Massive Open Online Courses (MOOCs) on the e-learning processes among autonomous engineering colleges in Tamil Nadu. As the landscape of higher education increasingly embraces digital platforms, understanding how students perceive and engage with MOOCs is crucial for optimizing educational outcomes. The review synthesizes existing research on various aspects of MOOC utilization, including factors influencing student awareness, the perceived effectiveness of MOOCs in enhancing learning experiences, and the challenges faced by students in accessing these resources. It highlights the role of institutional support, technological infrastructure, and student attitudes towards online learning in shaping perceptions of MOOCs. Additionally, the review explores the correlation between awareness of MOOCs and student engagement levels, academic performance, and overall satisfaction with the e-learning process. By identifying gaps in the current literature and suggesting directions for future research, this study aims to provide insights that can inform policymakers, educators, and institutions in effectively integrating MOOCs into their educational frameworks, thereby enhancing the learning experience for engineering students in Tamil Nadu.

Keywords: Massive Open Online Courses (MOOCs), Autonomous Colleges, Chi-Square Test, Correlation Analysis





INTRODUCTION

The advent of technology has revolutionized the educational landscape, with Massive Open Online Courses (MOOCs) emerging as a significant mode of e-learning. MOOCs offer an unprecedented opportunity for learners to access high-quality educational resources from renowned institutions, transcending geographical barriers and traditional classroom settings. In recent years, particularly within the context of autonomous engineering colleges in Tamil Nadu, there has been a growing interest in understanding the awareness and perception of MOOCs among students and educators alike [1] [2]. Tamil Nadu, a state in southern India known for its strong emphasis on education, is home to numerous autonomous engineering colleges that cater to a diverse student population. These institutions have been pivotal in shaping the technical education sector, producing skilled engineers who contribute significantly to the workforce. However, as educational methodologies evolve, it becomes crucial to assess how well these institutions and their stakeholders are adapting to the integration of e-learning resources, particularly MOOCs. This study aims to fill this gap by investigating the awareness levels and perceptions of MOOC e-learning resources among students and faculty in these colleges[3].

Awareness of MOOCs encompasses the knowledge of their existence, the platforms offering these courses, and the subjects covered. Perception, on the other hand, relates to the attitudes, beliefs, and perceived value of MOOCs in the context of traditional learning paradigms. Understanding these factors is essential for several reasons. Firstly, awareness can significantly influence the adoption of e-learning resources. If students and faculty are not aware of the availability and potential benefits of MOOCs, they are less likely to utilize them effectively. Secondly, perceptions regarding the quality, credibility, and relevance of MOOCs can shape attitudes towards their integration into formal education. Positive perceptions may lead to greater acceptance and usage, while negative perceptions could hinder their implementation [4] [5]. This study will employ a mixed-methods approach, combining quantitative surveys and qualitative interviews to gather comprehensive data on the awareness and perception of MOOCs. The findings will provide valuable insights into the current state of e-learning in autonomous engineering colleges in Tamil Nadu and will highlight potential areas for improvement. Additionally, the study aims to contribute to the broader discourse on the effectiveness of MOOCs as an educational tool and their role in enhancing learning outcomes in higher education. As engineering education continues to evolve in response to technological advancements, it is imperative to assess the awareness and perceptions of MOOC e-learning resources. This study will not only shed light on the current landscape in Tamil Nadu's autonomous engineering colleges but also serve as a foundation for future research and policy-making in the realm of e-learning. By understanding the perspectives of both students and faculty, stakeholders can make informed decisions that will enhance the quality and accessibility of education in this rapidly changing environment.

MASSIVE OPEN ONLINE COURSES (MOOCs)

The concept of Massive Open Online Courses (MOOCs) emerged in the early 2000s, propelled by advancements in technology and the growing demand for accessible, high-quality education. MOOCs are characterized by their ability to accommodate an unlimited number of participants, providing learners worldwide with the opportunity to access educational resources online, often for free or at a minimal cost [6]. The rise of MOOCs has transformed the educational landscape, offering new avenues for learning and challenging traditional educational paradigms.

Origin and Development

The term "MOOC" was first coined in 2008 by Dave Cormier, referring to a course titled "Connectivism and Connective Knowledge," which was designed by George Siemens and Stephen Downes. This course attracted over 2,000 participants, demonstrating the potential of online learning environments to reach large audiences. The initial success of this model prompted the development of other MOOCs, particularly by prominent universities, which sought to leverage their expertise and resources to a global audience [7]. By 2012, MOOCs gained significant traction with the launch of platforms such as Coursera, edX, and Udacity, which partnered with prestigious institutions like Stanford, Harvard, and MIT. These platforms expanded the reach of MOOCs, allowing universities to offer courses





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across various disciplines, from computer science and engineering to humanities and social sciences. This period marked a paradigm shift in higher education, where the boundaries of traditional classroom settings were blurred, enabling learners to participate in courses from anywhere in the world.

Characteristics of MOOCs

MOOCs typically feature a range of elements that distinguish them from conventional educational models [8]:

Open Access: MOOCs are designed to be accessible to anyone with an internet connection, removing barriers related to enrollment and tuition fees. This inclusivity promotes lifelong learning and democratizes education.

Massive Scale: MOOCs can accommodate thousands, if not millions, of participants simultaneously. This scalability is facilitated by online platforms that host course materials, discussion forums, and assessments.

Diverse Learning Materials: MOOCs utilize various instructional methods, including video lectures, interactive quizzes, reading materials, and discussion forums. This multimedia approach caters to different learning styles and preferences.

Peer Interaction: Many MOOCs incorporate social learning elements, allowing participants to interact with one another through forums, group projects, and peer assessments. This collaborative environment fosters knowledge exchange and enhances the learning experience.

Self-Paced Learning: MOOCs often allow learners to progress through courses at their own pace, accommodating diverse schedules and learning speeds. This flexibility empowers learners to take ownership of their education.

Impact on Education

The introduction of MOOCs has had profound implications for the education sector. They have expanded access to quality education, particularly for individuals in remote or underserved areas. Moreover, MOOCs have prompted educational institutions to reconsider their teaching methods, curricular offerings, and assessment strategies. The integration of online learning resources into traditional classrooms has encouraged blended learning models, combining face-to-face instruction with online components [9]. However, the rapid proliferation of MOOCs has also raised concerns about their effectiveness, quality, and sustainability. Critics argue that while MOOCs provide access, they may not always deliver the same educational value as traditional classroom experiences. Issues related to course completion rates, learner engagement, and credential recognition have been subjects of ongoing research.

Importance of MOOCs In Engineering Colleges

The integration of Massive Open Online Courses (MOOCs) in engineering colleges represents a significant evolution in the field of technical education. As engineering disciplines rapidly advance due to technological innovations and changing industry demands, traditional educational approaches often struggle to keep pace. MOOCs have emerged as a viable solution, providing flexible, accessible, and diverse learning resources that can enhance the educational experience for engineering students [10].

Addressing Educational Gaps

Engineering colleges face numerous challenges, including the need to keep curricula current and relevant. Traditional classroom instruction may not always offer the breadth and depth of knowledge required for rapidly evolving fields like artificial intelligence, data science, and renewable energy technologies. MOOCs address this gap by providing access to up-to-date content created by experts from leading institutions and organizations. This enables students to explore emerging topics and technologies that may not be fully covered in their formal education. Additionally, MOOCs can supplement the existing curriculum by offering specialized courses that delve deeper into niche areas of engineering. For instance, a student studying mechanical engineering may benefit from a MOOC on



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advanced robotics or materials science. This access to diverse content can enrich the learning experience and foster a culture of continuous learning among engineering students.

Enhancing Practical Skills

In engineering education, practical skills are critical for students' success in the workforce. MOOCs often incorporate hands-on projects, simulations, and real-world case studies, allowing learners to apply theoretical concepts in practical contexts. By engaging in these activities, students can develop essential problem-solving skills and gain experience with industry-relevant tools and technologies. This experiential learning is particularly valuable in fields where technical proficiency is crucial, such as software engineering, civil engineering, and electrical engineering. Furthermore, many MOOCs emphasize collaboration and peer learning through discussion forums and group projects. These interactions provide students with opportunities to work in teams, a key competency in engineering careers. Such collaborative experiences help students build soft skills, including communication, teamwork, and adaptability, which are vital for success in the workplace.

Promoting Lifelong Learning

The dynamic nature of the engineering field necessitates a commitment to lifelong learning. As new technologies and methodologies emerge, professionals must continually update their knowledge and skills. MOOCs facilitate this by offering flexible learning pathways that allow both current students and working professionals to engage with new content at their own pace. This adaptability supports the development of a growth mindset, encouraging engineers to seek out new knowledge and skills throughout their careers. Incorporating MOOCs into engineering education also fosters a culture of self-directed learning. Students learn to take initiative in their educational journey, exploring topics of interest beyond their prescribed curricula. This independence is crucial for future engineers, who will need to stay informed and adapt to the changing demands of their industries.

Bridging the Gap Between Academia and Industry

Another significant advantage of MOOCs in engineering colleges is their potential to bridge the gap between academic learning and industry needs. Many MOOCs are developed in collaboration with industry leaders, ensuring that the content is relevant and aligned with current workforce demands. By integrating these courses into their programs, engineering colleges can better prepare students for the challenges they will face in the professional world. Furthermore, MOOCs often provide access to resources such as industry case studies, expert lectures, and insights into best practices. This exposure enhances students' understanding of real-world applications and expectations, making them more competitive in the job market.

LITERATURE REVIEW ON MOOCs

Voudoukis, Nikolaos, and Gerasimos Pagiatakis [11] This study aims to elucidate the concept of Massive Online Open Courses (MOOCs), along with the associated practices, trends, and issues faced by higher education institutions. Despite their brief history, MOOCs experienced significant growth in 2012 when MIT and Harvard established "edX," former Stanford professors launched "Coursera," a corporate entity introduced "Udacity," and the UK's Open University initiated "Future Learn." Currently, most academic institutions in the US and Europe provide MOOCs to their students, presenting a diverse array of online courses across various areas, with the option to get a course certificate if desired. The emergence of MOOCs has significantly impacted global higher education, as learners now possess enhanced access and increased options for their education, compelling higher education institutions to reassess their pedagogical strategies and align with contemporary educational trends. Numerous factors motivate students to engage in a MOOC. Zubkov, Artyom [12] This study investigates the challenges associated with utilising massive open online courses to arrange language instruction in foreign languages for aspiring economists enrolled in undergraduate programs at Transport University. The demands of the contemporary labour market and global circumstances necessitate the implementation of novel approaches in the professional training process, and transportation university's foreign language program is no exception. The author examines



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massive open online courses in foreign languages as a creative approach to teaching a foreign language to Economics students at Transport University. We looked at the top internet platforms to see if they were relevant to the study question. Massive Open Online Courses (MOOCs) that satisfy state and federal educational standards, STU curriculum, and the disciplines applied at the "English Language" department were chosen.

Laaser, Wolfram [13] The discussion around "massive open online courses" (MOOCs), which first surfaced in 2008 and have since spread like a "Tsunami" among European educators and universities, is summarised in this paper. However, the definition of MOOCs, often known as "disruptive educational innovation," is not very clear, which has caused some annoyance and scepticism. As a result, the concepts that MOOCs are built upon will be discussed, and the pedagogical and technological context will be clarified through in-depth accounts of real-world cases. After laying out the background, the elements that contributed to the initial excitement surrounding MOOCs will be examined, along with the criticism that will soon be levelled at the claims made by those who support them. The ups and downs in expectations surrounding the introduction of educational breakthroughs are well-illustrated by the Gartner hype cycle model. A quick retrospective on earlier advancements in remote learning will be included to enhance the conversation. Agasisti, Tommaso, Giovanni Azzone, and Mara Soncin [14] The purpose of the current study is to evaluate the impact of Massive Open Online Courses (MOOCs) specifically for the purpose of remedial education. The information relates to Politecnico di Milano, the flagship institution of Italy, where a MOOC platform was introduced in accordance with the "MOOCs to bridge the gaps" approach. Thus, the study's objective is to evaluate how finishing a MOOC that served as a physics foundation course affected the students' performance on the ensuing on-campus physics exam (N = 2,830). Propensity Score Matching (PSM) was employed in the study, with the propensity scores being based on the students' academic and personal data.

De Moura, Valéria Feitosa, Cesar Alexandre de Souza, and Adriana Backx Noronha Viana [15] The purpose of this research is to better understand how blended learning can incorporate MOOCs. In order to achieve this, an exploratory case study in the field of Fundamentals of Administration at a Brazilian university was conducted in order to assess three factors: (1) the pedagogical approach and rationale; (2) the pedagogical and instructional design for incorporating the MOOC into the course; and (3) the students' perceptions of the MOOC's quality and value. The findings demonstrate that the MOOC was implemented as a blended learning technique in an introductory course, taking the place of some of the in-person class hours. This allowed for an increase in the number of students per teacher while also increasing student interest in the field. Akhmetshin, Elvir, *et al.* [16] In order to serve the interests of all parties involved in the educational process and national innovation (educational) strategy, this study aims to determine the prerequisites, including pedagogical ones, for the successful development and operation of MOOCs. The current work is grounded in the traditional scientific research methodology, which encompasses a range of scientific techniques like logical analysis of past events, dialectical observation of the environment, conceptual analysis of concepts in relation to their contradictory aspects, determining the causes and relationships between phenomena, abstracting and defining findings, and multiple-thematic comparative research. Sociological surveys are the method used in this study to gather empirical data. Moreover, it makes use of statistical and graphical data processing techniques. Additional techniques used are the examination of pertinent contemporary scientific literature and the synthesis of innovative ideas that show promise for the advancement of universities utilising digital learning technology. In order to interview teachers and students about the proposed research topic, pertinent questionnaires were created. Students' attitudes towards MOOCs and digital instructional technology are generally good.

Arkorful, Valentina, Kwaku Anhwere Barfi, and Nyinaku Odoi Baffour [17] The study looked at how students' perceived knowledge of Massive Open Online Courses (MOOCs) affects their utilisation of them. The study looks at what influences students' utilisation of MOOCs in Ghanaian universities using the Innovation Diffusion Theory and the Technology Acceptance Model. The Statistical Package for the Social Sciences was used to analyse the data. Structural Equation Modelling was used to analyse the data (SEM-Amos). The results demonstrated that students' use of MOOC systems is positively impacted by their perceptions of the systems' perceived usefulness, perceived simplicity of use, compatibility, and observability. However, students' use of MOOCs systems is adversely affected by their perception of the systems' complexity. Guerrero, Maribel, Sohvi Heaton, and David Urbano [18] Over the



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past few years, massive open online courses, or MOOCs, have drawn a lot of attention. While the educational and technological components of MOOCs have been extensively discussed in the literature, there is a dearth of actual data supporting MOOCs' impact on university outcomes. To close this gap, this study will examine the relationships between three key areas: (a) ordinary capabilities required to accomplish the university's core strategies (i.e., teaching quality, research quality, and administrative quality); (b) intrapreneurial capabilities required to accomplish the university's entrepreneurial strategy (i.e., MOOC orientation by taking on risks, sensing opportunities, and changing routines to become more innovative and proactive); and (c) the expected outcomes from these strategies (i.e., prestige in teaching/research, drawing in local and international students, and income structure diversification). Results from an analysis of 145 universities worldwide demonstrate that MOOC-based intrapreneurial capabilities both directly and indirectly contribute to the achievement of university outcomes. They do this by mediating the favourable impact of the university's ordinary capabilities on the outcomes of the university.

Li, Yong. [19] 175 students enrolled in the School of Marxism's massive open online courses (MOOCs) at a university in the province of Henan were chosen as responders for this study. Using SPSS22.0, a hierarchical clustering analysis was performed, and k-means clustering was used to categorise learners' learning preferences. Data envelopment analysis (DEA) was used to evaluate the learners' learning efficiency, and a variance test was used to examine the variations in learners' learning styles in learning inputs and learning outputs. The findings showed that four classes could be formed from the learning behavioural markers of MOOC learners using hierarchical clustering analysis. Learning styles can be categorised into four groups based on the outcomes of k-means clustering: high-input-high-output, high-input-low-output, low-input-high-output, and low-input-low-output. Asten, Tamara, and Ekaterina Egorova [20] In order to utilise mass open online courses as an extra educational resource for university students studying foreign languages, this study aims to compile an analytical review of the technologies of these courses, including their goals, objectives, pedagogical features, and technical aspects of the organisation. The study aims to perform a content analysis, categorisation, and generalisation of the findings concerning the pedagogical conditions and attributes of the most exemplary mass open online course examples in the Russian and global educational Internet resource segments. The competence-based and personality-oriented approaches to foreign language instruction at the university form the foundation of the study methodology. In order to achieve this, the study looked at the methodological and organisational aspects of the language courses offered by Universarium, Stepik, Lectorium, edX, Coursera, and Udemy, among other open education platforms. Systematising, condensing, and presenting the primary methodological and organisational features of educational platforms in terms of training structure and language course material was made feasible by the analysis.

Khalid, Asra, *et al.* [21] Information overload is a result of the exponential growth in the availability of online learning resources. Recommender systems that can suggest educational materials to users based on their interests have been presented as a solution to this issue. A massive amount of data is available in MOOCs, and this number grows as more students sign up. Poor quality recommendations are the outcome of traditional recommendation systems' scalability, sparsity, and cold start issues. Moreover, they are inappropriate for the dynamic environment of MOOCs since they are unable to handle the model's gradual updating upon the introduction of new data. Based on this line of inquiry, the authors suggest a unique online recommender system, called NoR-MOOCs, that solves a number of previously documented issues with recommender systems while also being accurate and scaling well with the data. Pampouri, A., *et al* [22] examined the tenets that underpin MOOC development and design, their philosophy and features, the learning theories that underpin them, and the essential components of a successful MOOC. The term MOOCs was coined in 2008 by Stephen Downes and George Siemens, and they can be broadly classified into two groups: cMOOCs, which prioritise participant contributions and social networking, and xMOOCs, which adhere to the behavioural model of learning approach. In summary, MOOCs promote lifelong learning and collaborative approaches, offer free, open, equitable, high-quality training, and may be used for either professional or personal growth, depending on the needs of the individual.

Longhini, Jessica, *et al.* [23] Distance learning has been heavily incorporated into healthcare sciences curricula in response to the recent challenges posed by the Coronavirus 2019 outbreak. Universities have also been urged to



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collaborate on learning opportunities in order to maintain educational continuity and the timely integration of newly graduated students into the healthcare system. Decisions on its introduction, however, ought to be backed by current data that can give a summary of the body of knowledge. To map the current status of research on massive open online courses (MOOCs) in undergraduate and graduate health sciences education, as well as the tools and assessment techniques used to quantify learning outcomes, and the elements that have been shown to increase MOOCs' effectiveness. Syahid, Adi, Khairol Anwar Kamri, and Siti Norbaya Azizan [24] carried out to assess MOOC-Open Learning's usefulness according to undergraduate students' opinions. A survey was distributed online to students enrolled in several undergraduate programs at Universiti Tun Hussein Onn Malaysia (UTHM), a public university in Malaysia, using the quantitative approach. According to the study's findings, respondents had generally moderately good evaluations of MOOC-OpenLearning's usability—that is, its utility, ease of use, ease of learning, and satisfaction—as support for their learning process. The results of this study suggest that respondents have serious doubts about MOOC-OpenLearning's usability, and that more research may be necessary to address the new issues that arise with its use.

Tao, Da, *et al.* [25] Within the context of the Technology Acceptance Model (TAM), this study aims to explore important aspects of user acceptance from interface design (i.e., usability), content quality (i.e., perceived quality), and emotional arousal (i.e., perceived enjoyment) of MOOCs. A self-reported questionnaire measuring TAM components and three hypothesised factors derived from MOOC features was distributed to 658 college students. Every path coefficient was found to be statistically significant based on the path analysis findings. Students' behavioural intention to use MOOCs was highly influenced by their perceptions of the courses' ease of use, utility, and enjoyment. Perceived effectiveness of MOOC use was significantly influenced by both behavioural intention and perceived usefulness. Bokova, Tatiana Nikolaevna, and Olga Aleksandrovna Kabanova [26] Using a comparative analysis and a review of the literature, this study tracks the growth of MOOCs and identifies some widely recognised blended learning models for higher education. This essay also makes an effort to illustrate the drawbacks and benefits of incorporating MOOCs into in-person instruction. The results focus on how Russian institutions may employ massively open online courses effectively.

Li, Yao [27] examined, from the standpoint of higher education, how globalisation of MOOCs affects equality in higher education and the growth pattern of MOOCs in higher education in Mainland China. Wong, Billy Tak-ming [28] studied the educational elements of language MOOCs, or massively open online courses, for language acquisition. Providing quick movies and reading materials for independent study, along with machine-graded quizzes for self-evaluation and discussion boards primarily for peer-to-peer communication on course material, is the standard MOOC methodology. The pedagogical aspects of pertinent MOOCs have not yet been thoroughly examined in relation to language acquisition, which has traditionally been viewed as skill development. Shrivastava, Archana, and Ashish Shrivastava [29] sought to ascertain which aspects of the online program are taken into account and calculate how significant a role each plays in the choice to buy. In order to help online education organisations create their product design strategy and draw in clients with the most appealing offering, this study tries to determine the most profitable bundling of these features and their respective levels. The goal of this study paper is to pinpoint the qualities of online learning that consumers take into account when choosing a product. The main characteristics of online education programs were determined using exploratory factor analysis and confirmatory factor analysis.

Zhou, Xinyu, *et al.* [30] The purpose of this research is to investigate the state of AI education in massively open online courses (MOOCs). To better understand the content and delivery strategies of AI education on MOOC platforms, we coded data on course overviews, content outlines, suggested materials, and teaching methodologies after screening 128 sample MOOC courses from ten learning platforms. The findings indicate that: (1) Companies and universities make up the majority of the organisations delivering MOOCs; (2) Coursera and Edx platforms offer the greatest number of ESD-related courses; and (3) the number of courses connected to AI education that have been offered since 2012 has been rising annually. AI courses are currently very popular, with an average enrolment of over 120,000 students; (2) the main content of AI education consists of topics related to typical applications and core



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algorithms; (3) the most popular pedagogical methods used in MOOCs at this time are online procedural teaching, task-driven teaching, and online collaborative learning.

Research Gaps

Despite the numerous benefits of MOOCs, their integration into engineering colleges is not without challenges. Issues such as course completion rates, learner engagement, and the recognition of MOOC credentials can affect their perceived value. Engineering colleges must address these concerns by implementing strategies that encourage participation, support learners, and ensure that MOOCs complement traditional educational approaches effectively.

Awareness and Accessibility: While MOOCs offer extensive resources, there is limited research on the level of awareness among students and faculty in Tamil Nadu's engineering colleges. Understanding the extent to which stakeholders are aware of available MOOCs, their features, and how to access them is crucial for promoting their adoption.

Perceptions and Attitudes: Research on the perceptions and attitudes of engineering students and faculty towards MOOCs in Tamil Nadu is scarce. Understanding how learners view the quality, credibility, and relevance of MOOCs compared to traditional classroom learning is vital. This includes exploring any biases or misconceptions that may exist and how they influence the acceptance and use of MOOCs in engineering education.

Impact on Learning Outcomes: While several studies have examined the effectiveness of MOOCs in various educational contexts, there is a need for specific research focused on engineering colleges in Tamil Nadu. Investigating the impact of MOOCs on students' academic performance, retention rates, and skill acquisition can provide valuable insights into their effectiveness as a supplementary educational resource. Additionally, comparative studies between MOOC participants and non-participants could shed light on the tangible benefits of MOOCs in engineering education.

Curriculum Integration: The integration of MOOCs into existing engineering curricula presents challenges and opportunities that require further exploration. Research is needed to identify best practices for incorporating MOOCs into traditional teaching methods, ensuring alignment with academic standards, and addressing potential curricular gaps. Additionally, studies could focus on the development of hybrid learning models that effectively combine MOOCs with face-to-face instruction.

Student Engagement and Completion Rates: Student engagement and course completion rates are critical factors influencing the success of MOOCs. However, there is a lack of research focusing on the specific engagement strategies that can be employed in engineering colleges in Tamil Nadu to enhance participation and motivation among students. Investigating factors that contribute to high dropout rates, such as course design, content relevance, and support mechanisms, is essential for improving completion rates.

Future Research Direction

As MOOCs continue to evolve, various trends are shaping their future. The integration of artificial intelligence and personalized learning technologies is enhancing the adaptability of MOOCs, allowing for tailored learning experiences. Additionally, the development of micro-credentials and stackable courses is creating new pathways for learners to gain recognized qualifications in specific fields. In summary, MOOCs represent a significant development in the educational landscape, offering unprecedented access to learning resources and fostering new ways of knowledge acquisition. As they continue to evolve, ongoing research and assessment of their impact, effectiveness, and potential will be crucial in shaping the future of education. Understanding the dynamics of MOOCs is essential for stakeholders, including educators, policymakers, and learners, as they navigate this transformative era in education.





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An Ensemble Framework Approach to Crop Type Prediction Using Feature Selection and Multiclass Classification

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ABSTRACT

Crop type classification plays a crucial role in modern agriculture, aiding in yield prediction, resource management, and land-use planning. This paper presents a comprehensive framework for crop type classification utilizing a combination of feature selection techniques, robust classification Algorithm, and a Support Vector Machine (SVM)-based multiclass classification approach. The proposed framework begins with a novel feature selection process that identifies the most relevant attributes from the Agricultural Data and Rainfall data. This feature selection step is essential for reducing data dimensionality, enhancing classification accuracy, and improving model interpretability. Following feature selection, a state-of-the-art multiclass classification strategy based on Support Vector Machines is employed. SVMs are known for their capability to handle high-dimensional data and have demonstrated superior performance in various classification tasks. In this framework, SVMs are adapted to handle multiclass crop type classification efficiently. The model is trained on the selected features and optimized using hyper parameter tuning techniques to ensure robust performance.

Keywords: Crop Classification, Machine Learning, Feature Selection, Classification, Multi-Class Classification, Support Vector Machine





INTRODUCTION

In the realm of modern agriculture and remote sensing, the accurate classification of crop types is a pivotal task with profound implications for crop management, yield prediction, resource allocation, and land-use planning. Accurate identification and mapping of crop types from satellite and aerial imagery have the potential to revolutionize precision agriculture and aid in optimizing farming practices [1] [2]. To achieve this, researchers and practitioners have turned to advanced data-driven techniques, leveraging feature selection, classification algorithms, and multiclass classification strategies. Crop type classification, a subset of remote sensing applications, involves the categorization of agricultural fields into specific crop classes, such as wheat, maize, rice, soybeans, and more. This classification not only informs farmers about the distribution of crops in their fields but also assists in monitoring crop health, identifying pest or disease outbreaks, and guiding decisions related to irrigation and fertilization [3] [4]. This paper delves into the realm of "Crop Type Classification using Feature Selection, Classification, and Multiclass Classification Techniques," where a multidisciplinary approach is adopted to address the challenges and opportunities in this field. We explore the fusion of three fundamental components:

Feature Selection: Remote sensing datasets often contain a multitude of spectral, spatial, and temporal attributes. Feature selection techniques play a vital role in extracting the most informative and discriminative features from this wealth of data. By identifying key features, we can not only reduce dimensionality but also enhance the efficiency and effectiveness of subsequent classification algorithms. The choice of feature selection method can significantly impact the accuracy and computational efficiency of crop type classification models [5][6] [30] [31].

Classification Algorithms: Once relevant features are extracted, the next step is to employ robust classification algorithms capable of accurately categorizing the data into different crop types. These algorithms range from traditional machine learning approaches like decision trees and random forests to more advanced techniques such as support vector machines (SVMs) and deep learning models. The choice of classification algorithm is pivotal to the overall performance and generalization ability of the crop type classification system [7] [8] [25] [26].

Multiclass Classification: Real-world agricultural landscapes are characterized by the coexistence of multiple crop types within the same geographic region. Therefore, a practical crop type classification system must be capable of handling multiclass scenarios where more than two crop types need to be differentiated. Multiclass classification strategies, including one-vs-all, one-vs-one, and softmax-based approaches, become essential to ensure accurate and comprehensive crop type mapping [9] [10] [27] [28] [29]. This paper explores the integration of these three components into a cohesive framework for crop type classification. Through extensive experiments on diverse agricultural datasets, we evaluate the efficacy and performance of different feature selection methods, classification algorithms, and multiclass classification techniques. Ultimately, this research aims to advance the state of the art in crop type classification, providing valuable insights and tools for precision agriculture and sustainable food production.

Related Works

Kalimuthu, M., P. Vaishnavi, and M. Kishore [11] This research study aims to assist novice farmers by utilising machine learning, an advanced technology in crop prediction, to provide guidance on selecting suitable crops for cultivation. The Naive Bayes algorithm, which is a supervised learning technique, proposes a methodology for its implementation. The collection of seed data for crops occurs at this location, taking into account specific parameters such as temperature, humidity, and moisture content. These factors contribute to the favourable conditions necessary for the effective growth of crops. Furthermore, with the software, there is ongoing development of a mobile application specifically designed for the Android operating system. Users are prompted to input factors like as temperature, and their location is automatically retrieved by the programme to initiate the prediction procedure. Nischitha, K., *et al* [12] The system was developed utilising machine learning algorithms with the objective of



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enhancing the agricultural practises for the benefit of farmers. The suggested approach aims to provide recommendations for the most appropriate crop selection for a given land area, taking into consideration factors such as soil composition and meteorological conditions. Additionally, the system offers information pertaining to the necessary substance and quantity of fertilisers, as well as the requisite seeds for cultivation. Therefore, with the implementation of the suggested approach, farmers have the ability to cultivate a novel crop variety, potentially leading to an increase in their profit margin, while also mitigating the risk of soil pollution.

Rao, Madhuri Shripathi, *et al* [13] The objective of this study was to identify the optimal model for crop prediction, with the intention of assisting farmers in making informed decisions regarding crop selection, taking into account weather conditions and soil nutrient levels. This study conducted a comparative analysis of commonly used algorithms, namely K-Nearest Neighbour (KNN), Decision Tree, and Random Forest Classifier, employing two distinct criteria, Gini and Entropy. Gupta, Archana, *et al.* [14] Agriculture plays a crucial role in driving economic growth. The maintenance of a healthy biosphere is contingent upon this factor. A diverse array of agricultural products plays a crucial role in several facets of human existence, upon which individuals heavily rely. Farmers are required to effectively adapt to the challenges posed by climate change while simultaneously fulfilling the increasing requirements for greater quantities of food with enhanced nutritional value. To enhance agricultural output and growth, farmers must possess knowledge of the prevailing climatic circumstances, which informs their decision-making process regarding the cultivation of appropriate crops within those specific environmental elements. The implementation of Internet of Things (IoT) technology in the context of Smart Farming has demonstrated significant enhancements to the overall efficiency and effectiveness of the Agriculture system through the real-time monitoring of fields. The system effectively monitors and regulates many variables like as humidity, temperature, and soil conditions, providing accurate and immediate real-time observations. The application of machine learning techniques in the agricultural domain aims to enhance crop productivity and quality. The utilisation of relevant algorithms on the collected data has the potential to facilitate the recommendation of appropriate crops.

Kumar, Y. Jeevan Nagendra, *et al.* [15] Machine learning (ML) plays a vital role in obtaining practical and effective solutions for the problem of crop yield. Supervised Learning in Machine Learning enables the prediction of a target or outcome based on a predetermined set of predictors. In order to obtain the desired outcomes, it is necessary to create an appropriate function that incorporates a collection of variables. This function will effectively transfer the input variable to the intended output. The process of crop yield prediction involves utilising historical data to forecast the anticipated yield of a specific crop. This historical data encompasses various parameters, including temperature, humidity, pH levels, rainfall, and the specific crop being analysed. It provides us with an indication of the optimal projected crop that can be cultivated under specific field weather circumstances. The task of making predictions can be accomplished through the utilisation of a machine learning algorithm known as Random Forest. The system will generate crop predictions with the highest level of accuracy. The random forest approach is employed to generate an optimal crop yield model while minimising the number of models considered. Predicting crop yield in the agricultural sector is highly advantageous. Elavarasan, Dhivya, and PM Durairaj Vincent [16] The present study aims to develop a Deep Recurrent Q-Network model, which is a deep learning algorithm based on Recurrent Neural Network architecture, to predict crop yield using the Q-Learning reinforcement learning method. The data parameters are used to feed the successively stacked layers of a Recurrent Neural Network. The Q-learning network establishes an environment for predicting agricultural productivity by utilising input parameters. The mapping of output values from a Recurrent Neural Network to Q-values is achieved through the utilisation of a linear layer. The reinforcement learning agent utilises a hybrid approach, combining parametric features and a threshold mechanism, to effectively forecast crop yield. Ultimately, the agent obtains a comprehensive score based on its executed actions, aiming to minimise errors and maximise the accuracy of its predictions. The suggested model demonstrates a high level of efficiency in predicting crop production, surpassing the performance of existing models. This is achieved by effectively conserving the original data distribution, resulting in an accuracy rate of 93.7%.

Reddy, D. Jayanarayana, and M. Rudra Kumar [17] I conducted a systematic review that involved the extraction and synthesis of features utilised for the prediction of crop yield, specifically focusing on the cytochrome P450 enzyme



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system (CYP). Additionally, a diverse range of methodologies have been developed to analyse crop yield prediction, including approaches derived from artificial intelligence. The primary constraints associated with Neural Networks pertain to the decrease in relative error and diminished predictive efficacy in the context of Crop Yield. In a similar vein, the limitations of supervised learning methods became apparent when attempting to capture the complex relationship between input and output variables in the context of fruit grading or sorting. Numerous research were proposed to enhance agricultural development, with the objective of establishing a precise and effective framework for crop classification. This framework encompasses various aspects, including crop yield estimation based on meteorological conditions, identification of crop diseases, and categorization of crops according to their growth stages. This study investigates the application of machine learning (ML) techniques in the domain of crop yield estimation. It offers a comprehensive examination of the accuracy of these techniques through a detailed analysis. Pant, Janmejey, *et al* [18] This work employs machine learning techniques to forecast the yields of four commonly farmed crops across several regions in India. Once the prediction of crop production is conducted with site-specificity, the application of inputs, such as fertilisers, can be adjusted accordingly based on the anticipated requirements of the crop and soil. In this work, Machine Learning methodologies are employed to construct a trained model that facilitates the identification of patterns within data, specifically for the purpose of crop prediction. This work focuses on the application of machine learning techniques to forecast the yields of the four most commonly farmed crops in India. The crops encompassed in this category are maize, potatoes, rice (paddy), and wheat.

Paudel, Dilli, *et al* [19] The integration of agronomic concepts of crop modelling with machine learning techniques was employed to establish a machine learning baseline for the purpose of forecasting crop yield on a wide scale. The fundamental principle of this workflow is to prioritise consistency, modularity, and reusability. In order to ensure accuracy, the authors prioritised the development of interpretable predictors or features pertaining to crop growth and development, as well as the implementation of machine learning techniques that prevent the inadvertent disclosure of information. The features were generated by the authors through the utilisation of crop simulation outputs, as well as weather, remote sensing, and soil data obtained from the MCYFS database. The authors placed significant emphasis on a modular and reusable process that can effectively accommodate various crops and countries through minor configuration adjustments. The workflow has the capability to execute replicable experiments, such as forecasts made at the beginning or conclusion of a season, by utilising standardised input data in order to achieve findings that can be reproduced. The findings provide a foundation for future enhancements. In the context of our case studies, we made projections regarding agricultural production at a regional scale for five specific crops, namely soft wheat, spring barley, sunflower, sugar beetroot and potatoes. These projections were conducted for three nations, namely the Netherlands (NL), Germany (DE) and France (FR). We conducted a performance comparison between a basic technique lacking predictive ability, which involved predicting either a linear yield trend or the average of the training set. Nishant, Potnuru Sai, *et al*. [20] The study aimed to forecast the agricultural output of several crop varieties cultivated in India. This script employs basic criteria such as State, district, season, and area to facilitate the prediction of crop yield for a specified year. This study employed advanced regression approaches, including Kernel Ridge, Lasso, and Enet algorithms, to forecast yield. Additionally, the concept of Stacking Regression was utilised to enhance the algorithms and improve the accuracy of the predictions.

Proposed Framework for Crop Type Prediction Using Machine Learning Techniques

Figure 1 depicts the Proposed Framework for the Crop Type Prediction using Proposed Feature Selection, Classification and Multi Class Classification methods.

Proposed Gain Ratio Differential Evolution Feature Selection (GRDEFS) Method

Feature selection is a critical step in data preprocessing and machine learning model development, as it directly impacts the efficiency and effectiveness of predictive algorithms. This paper introduces the Gain Ratio Differential Evolution Feature Selection (GRDEFS) method [24], a novel and powerful approach designed to address the challenges of feature selection in high-dimensional datasets. GRDEFS combines the Gain Ratio metric, which measures the relevance of features, with the Differential Evolution optimization algorithm, known for its ability to search for global optima efficiently. The GRDEFS method begins by calculating the Gain Ratio for each feature,





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providing a quantitative measure of the feature's contribution to the classification task. The Differential Evolution algorithm is then employed to search for an optimal subset of features based on the Gain Ratio values. By treating the feature selection process as an optimization problem, GRDEFS efficiently explores the feature space to identify the subset of features that maximizes classification performance while minimizing dimensionality.

Proposed Optimized Artificial Neural Network (OANN) Classification Method

Artificial Neural Networks (ANNs) have proven to be potent tools for solving intricate classification tasks, but they often face challenges related to convergence and local minima. In this study, we propose an innovative approach that harnesses the strengths of both ANNs and Gradient Boosting Machines (GBMs) to enhance classification accuracy and reduce error rates. The novel method begins by initializing ANN architecture with appropriate hyper parameters. To overcome the convergence and over fitting issues often associated with ANNs, we introduce a GBM-based optimization step. This step acts as a dynamic learning rate controller, adjusting the ANN's weights during training to minimize error rates effectively [25]. The GBM-driven optimization process continuously evaluates the ANN's performance on a validation dataset and updates the network's weights accordingly. This adaptive learning strategy ensures that the ANN converges faster and escapes local minima more efficiently. Additionally, it reduces over fitting by preventing the network from memorizing noise in the training data.

Proposed Enhanced Support Vector Machine based Multi Class Classification Method

Support Vector Machine (SVM) algorithms have gained prominence in the realm of machine learning for their effectiveness in binary classification tasks. However, when extended to multi-class classification scenarios, traditional SVMs encounter challenges related to scalability and interpretability. In this study, we introduce an innovative approach that enhances SVM's multi-class classification performance by integrating it with the Logistic Regression-Based SVM Multiclass Method. The proposed method leverages the robustness of traditional SVMs in capturing non-linear decision boundaries while simultaneously harnessing the simplicity and interpretability of Logistic Regression. The key innovation lies in extending the binary SVM approach to multiple classes, ensuring efficient class separation without compromising computational efficiency. The logistic regression-based SVM multiclass method is seamlessly integrated into the SVM framework to create a unified model that optimizes class separation by considering both the SVM margin and logistic regression loss. This integration provides a balanced trade-off between model complexity and classification accuracy, making it well-suited for various multi-class classification tasks.

RESULT AND DISCUSSION

Performance Metrics

Table 1 depicts the Performance Metrics used in this research work.

Description of the Dataset

The Indian crop yield prediction and estimation dataset are taken from Kaggle repository [23]. The dataset is composed of 7 features. Among the 7 features, state_name features have 33 distinct values, district_name have 646 distinct values, crop_year have 19 distinct years, crop features have 124 crops types and season features have 6 seasons. In this dataset, only Tamilnadu State and its 31 districts are considered in this research to evaluate the multiclass classification model for predicting the major crops like Rice, jowar, ragi, bajra, maize, and pulses. For training the model, crop cultivated year of 1997 to 2013 and only three seasons (Kharif, Rabi and Whole Year) are considered since the above-mentioned crops are cultivated during these seasons. Table 2 depicts the description of Indian Crop Yield Estimation Dataset [R].

In this research work, Feature Encoding is done with Label Encoding for the categorical features in the dataset. After the pre-processing step of Label Encoding, the dataset considered in this research work have one state name (Tamilnadu), 31 districts, 17 years of crop cultivation, 3 seasons of crop cultivation, area and production. So, totally, 54 are obtained after the Feature Encoding. In the feature selection step, Proposed Gain Ratio Differential Evolution



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Feature Selection (GRDEFS) method [] is used. The performance of the Proposed Logistic Regression based SVM multiclass (LR-SVM-MC) Method is evaluated with the existing classification techniques like Support Vector Machine (SVM), Logistic Regression Classification (LR) Method and Random Forest (RF) Classification Method using the proposed and existing feature selection methods processed datasets. Table 3 depicts the number of features obtained by original dataset, Proposed GRDEFS, Gain Ratio (GR), and Differential Evolution (DE) based feature selections processed datasets. From the table 3, it is clear that the proposed GRDEFS method gives less number of features than the existing feature selection methods.

Table 4 depicts the Classification Accuracy (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets. In Table 4, the classification accuracy (expressed in percentage) achieved by various classification methods using feature selection techniques is presented. The methods compared are the Proposed LR-SVM-MC, SVM, LR, and RF. For the original dataset, the Proposed LR-SVM-MC achieved a classification accuracy of 53.76%, while SVM, LR, and RF achieved lower accuracies of 48.23%, 45.67%, and 40.32% respectively. Upon applying the GR (Genetic Algorithm Ranking) feature selection technique, significant improvements in classification accuracy were observed across all classification methods. The Proposed LR-SVM-MC exhibited the highest accuracy of 79.43%, followed by SVM with 67.49%, LR with 66.17%, and RF with 63.52%. When the DE (Differential Evolution) feature selection technique was employed, improvements in accuracy were again seen. The Proposed LR-SVM-MC achieved an accuracy of 60.42%, while SVM, LR, and RF achieved accuracies of 58.39%, 57.42%, and 54.71% respectively.

The Proposed GRDEFS (Genetic Algorithm and Differential Evolution Feature Selection) technique led to the highest accuracy values among all experiments. The Proposed LR-SVM-MC achieved an impressive accuracy of 95.66%, followed by SVM with 83.67%, LR with 89.45%, and RF with 79.22%. Overall, the results highlight the effectiveness of the Proposed LR-SVM-MC and feature selection techniques, particularly the combined GRDEFS approach, in significantly enhancing the classification accuracy of the various classification methods. Table 5 depicts the Recall (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets.

In Table 5, the recall values (in %) obtained from various classification methods using feature selection techniques are presented. The compared methods are the Proposed LR-SVM-MC, SVM, LR, and RF. For the original dataset, the Proposed LR-SVM-MC achieved a recall value of 49.81%, while SVM, LR, and RF achieved lower recall values of 45.85%, 42.26%, and 40.85% respectively. Applying the GR feature selection technique resulted in improved recall values across all classification methods. The Proposed LR-SVM-MC achieved the highest recall of 73.46%, followed by SVM with 61.30%, LR with 60.62%, and RF with 57.22%. When the DE feature selection technique was utilized, recall values were again positively impacted. The Proposed LR-SVM-MC achieved a recall of 74.39%, while SVM, LR, and RF had recalls of 52.53%, 51.84%, and 48.81% respectively. The Proposed GRDEFS technique yielded the highest recall values in all experiments. The Proposed LR-SVM-MC achieved a substantial recall of 95.32%, followed by SVM with 80.48%, LR with 79.73%, and RF with 75.21%. These results emphasize the effectiveness of the Proposed LR-SVM-MC model, along with the feature selection techniques employed, particularly the combined GRDEFS approach. These techniques significantly enhanced the recall values of the various classification methods, demonstrating their potential for improving the identification of relevant instances in the dataset. Table 6 gives the False Positive Rate (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets.

In Table 6, the false positive rates (expressed in percentage) obtained from various classification methods using feature selection techniques are presented. The methods compared are the Proposed LR-SVM-MC, SVM, LR, and RF. For the original dataset, the Proposed LR-SVM-MC achieved a false positive rate of 65.51%, while SVM, LR, and RF achieved higher false positive rates of 68.78%, 70.35%, and 72.44% respectively. Applying the GR feature selection technique resulted in reduced false positive rates across all classification methods. The Proposed LR-SVM-MC achieved the lowest false positive rate of 34.81%, followed by SVM with 46.22%, LR with 54.64%, and RF with



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59.21%. When the DE feature selection technique was used, false positive rates were further lowered. The Proposed LR-SVM-MC achieved a false positive rate of 34.59%, while SVM, LR, and RF had false positive rates of 41.15%, 52.73%, and 55.87% respectively. The Proposed GRDEFS technique resulted in the lowest false positive rates in all experiments. The Proposed LR-SVM-MC achieved a remarkable false positive rate of 12.58%, followed by SVM with 20.43%, LR with 22.58%, and RF with 35.63%. These findings highlight the effectiveness of the Proposed LR-SVM-MC model and the feature selection techniques employed, particularly the combined GRDEFS approach, in significantly reducing false positive rates across the various classification methods. Table 7 gives the Precision (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets.

In Table 7, the precision values (in %) obtained from various classification methods using feature selection techniques are presented. The compared methods are the Proposed LR-SVM-MC, SVM, LR, and RF. For the original dataset, the Proposed LR-SVM-MC achieved a precision value of 57.85%, while SVM, LR, and RF achieved lower precision values of 50.53%, 48.77%, and 45.81% respectively. Applying the GR feature selection technique led to increased precision values across all classification methods. The Proposed LR-SVM-MC achieved the highest precision of 88.8%, followed by SVM with 81.73%, LR with 79.26%, and RF with 69.31%. When the DE feature selection technique was utilized, precision values were further enhanced. The Proposed LR-SVM-MC achieved a precision of 83.68%, while SVM, LR, and RF had precisions of 79.47%, 71.13%, and 67.41% respectively. The Proposed GRDEFS technique yielded the highest precision values in all experiments. The Proposed LR-SVM-MC achieved an exceptional precision of 95.72%, followed by SVM with 85.42%, LR with 82.57%, and RF with 78.52%. These results underscore the effectiveness of the Proposed LR-SVM-MC model and the feature selection techniques employed, particularly the combined GRDEFS approach. These techniques significantly improved the precision values of the various classification methods, highlighting their ability to correctly classify positive instances and minimize the rate of false positives. Table 8 gives the Specificity (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets.

In Table 8, the specificity values (in %) obtained from various classification methods using feature selection techniques are presented. The compared methods are the Proposed LR-SVM-MC, SVM, LR, and RF. For the original dataset, the Proposed LR-SVM-MC achieved a specificity value of 34.49%, while SVM, LR, and RF achieved slightly higher specificity values of 31.22%, 29.65%, and 27.56% respectively. Applying the GR feature selection technique resulted in increased specificity values across all classification methods. The Proposed LR-SVM-MC achieved the highest specificity of 65.19%, followed by SVM with 53.78%, LR with 45.36%, and RF with 40.79%. When the DE feature selection technique was employed, specificity values were further improved. The Proposed LR-SVM-MC achieved a specificity of 65.41%, while SVM, LR, and RF had specificities of 58.85%, 47.27%, and 44.13% respectively. The Proposed GRDEFS technique yielded the highest specificity values in all experiments. The Proposed LR-SVM-MC achieved a notable specificity of 87.42%, followed by SVM with 79.57%, LR with 77.42%, and RF with 64.37%. These results underscore the effectiveness of the Proposed LR-SVM-MC model and the feature selection techniques employed, particularly the combined GRDEFS approach. These techniques significantly enhanced the specificity values of the various classification methods, highlighting their ability to correctly classify negative instances and reduce the rate of false positives. Table 9 depicts the Miss Rate (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets.

Table 9 presents the Miss Rate (in %) obtained by various classification methods, including Proposed LR-SVM-MC, SVM, Logistic Regression (LR), and Random Forest (RF), when applied to feature selection processed datasets using different feature selection techniques. Without any feature selection, all classification methods had relatively high miss rates ranging from 50.19% to 59.15%. This indicates that the original dataset had a considerable degree of classification error. Applying the GR feature selection technique led to a significant reduction in the miss rate for all classification methods. The miss rates dropped to a range of 26.54% to 42.78%, indicating that feature selection improved classification accuracy. The DE feature selection technique also resulted in improved performance, with miss rates ranging from 25.61% to 51.19%. Similar to GR, DE helped reduce classification errors for all methods. The Proposed GRDEFS feature selection technique produced the lowest miss rates across all classification methods,



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ranging from 4.68% to 24.79%. This suggests that the combination of the Proposed GRDEFS technique and the Proposed LR-SVM-MC method was particularly effective in reducing classification errors. In summary, the data highlights the importance of feature selection in enhancing classification accuracy. Both GR and DE feature selection techniques led to substantial reductions in miss rates compared to the original dataset. The Proposed GRDEFS technique, in conjunction with Proposed LR-SVM-MC, performed exceptionally well in minimizing classification errors, underscoring its effectiveness in improving classification performance. This analysis emphasizes the significance of feature selection in optimizing machine learning models when dealing with complex and high-dimensional datasets. Table 10 gives the False Discovery Rate (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets.

Table 10 presents the False Discovery Rate (in %) obtained by various classification methods, including Proposed LR-SVM-MC, SVM, Logistic Regression (LR), and Random Forest (RF), when applied to feature selection processed datasets using different feature selection techniques. Without any feature selection, all classification methods had relatively high False Discovery Rates ranging from 42.15% to 54.19%. This indicates that the original dataset had a substantial number of false positive errors. Applying the GR feature selection technique led to a significant reduction in the False Discovery Rate for all classification methods. The False Discovery Rates dropped to a range of 11.2% to 30.69%, indicating that feature selection improved the ability to control false positive errors. The DE feature selection technique also resulted in improved performance, with False Discovery Rates ranging from 16.32% to 32.59%. Similar to GR, DE helped reduce false positive errors for all methods. The Proposed GRDEFS feature selection technique produced the lowest False Discovery Rates across all classification methods, ranging from 4.28% to 21.48%. This suggests that the combination of the Proposed GRDEFS technique and the Proposed LR-SVM-MC method was particularly effective in minimizing false positive errors. In summary, the data highlights the importance of feature selection in controlling false positive errors in classification. Both GR and DE feature selection techniques led to significant reductions in False Discovery Rates compared to the original dataset. The Proposed GRDEFS technique, when combined with Proposed LR-SVM-MC, demonstrated exceptional performance in minimizing false positive errors, underlining its effectiveness in improving the precision of classification models.

CONCLUSION

This paper presents a holistic and advanced framework for crop type classification that addresses the critical needs of modern agriculture. By combining feature selection techniques, a robust classification algorithm, and a Support Vector Machine-based multiclass classification approach, it offers a comprehensive solution for crop type prediction. The innovative feature selection process significantly contributes to data dimensionality reduction, improved classification accuracy, and enhanced model interpretability, laying the foundation for more precise and efficient crop classification. Leveraging the power of Support Vector Machines, the framework demonstrates its ability to handle high-dimensional data, thereby ensuring accurate crop type prediction.

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Table 1: Performance Metrics

Metrics	Equation
Accuracy	$\frac{TP + TN}{TP + TN + FP + FN}$
True Positive Rate (TPR) (Sensitivity or Recall)	$\frac{TP}{TP + FN}$
False Positive Rate	$\frac{FP}{FP + TN}$
Precision	$\frac{TP}{FP + TP}$
True Negative Rate (Specificity)	1- False Positive Rate
Miss Rate	1- True Positive Rate
False Discovery Rate	1-Precision

Table 2: Description of Indian Crop Yield Estimation Dataset

Sl.No	Feature Name	Description
1	State_Name	Depicts the state name of the crop obtained (TotalState Count: 33)
2	District_Name	Depicts the district name of the crops obtained(Total District Count: 646)
3	Crop_Year	Gives the crop cultivation year (Number of Years:19)
4	Season	Describes the various seasons that the crop hasbeen cultivated (Total number of Seasons: 6)
5	Crop	Describes the type of crops has been cultivated(Total Number of crop type: 124)
6	Area	Describes the area in sq.feet where the crops hasbeen cultivated
7	Production	Describes the production obtained by the crop

Table 3: Number of Features obtained by the Proposed and Existing Feature Selection Methods

Feature Selection Techniques	Number of Features obtained
Original dataset	54
GR	37
DE	35
Proposed GRDEFS	33

Table 4: Classification Accuracy (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets

Feature Selection Techniques	Classification Accuracy (in %) by Classification Methods			
	Proposed LR-SVM-MC	SVM	LR	RF
Original dataset	53.76	48.23	45.67	40.32
GR	79.43	67.49	66.17	63.52





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DE	71.42	58.39	57.42	54.71
Proposed GRDEFS	95.66	83.67	89.45	79.22

Table 5: Recall (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets

Feature Selection Techniques	Recall(in %) by Classification Methods			
	Proposed LR-SVM-MC	SVM	LR	RF
Original dataset	49.81	45.85	42.26	40.85
GR	73.46	61.30	60.62	57.22
DE	74.39	52.53	51.84	48.81
Proposed GRDEFS	95.32	80.48	79.73	75.21

Table 6: False Positive Rate (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets

Feature Selection Techniques	False Positive Rate(in %) by Classification Methods			
	Proposed LR-SVM-MC	SVM	LR	RF
Original dataset	65.51	68.78	70.35	72.44
GR	34.81	46.22	54.64	59.21
DE	34.59	41.15	52.73	55.87
Proposed GRDEFS	12.58	20.43	22.58	35.63

Table 7: Precision (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets

Feature Selection Techniques	Precision (in %) by Classification Methods			
	Proposed LR-SVM-MC	SVM	LR	RF
Original dataset	57.85	50.53	48.77	45.81
GR	88.8	81.73	79.26	69.31
DE	83.68	79.47	71.13	67.41
Proposed GRDEFS	95.72	85.42	82.57	78.52

Table 8: Specificity (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets

Feature Selection Techniques	Specificity(in %) by Classification Methods			
	Proposed LR-SVM-MC	SVM	LR	RF
Original dataset	34.49	31.22	29.65	27.56
GR	65.19	53.78	45.36	40.79
DE	65.41	58.85	47.27	44.13
Proposed GRDEFS	87.42	79.57	77.42	64.37

Table 9: Miss Rate (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets

Feature Selection Techniques	Miss Rate(in %) by Classification Methods			
	Proposed LR-SVM-MC	SVM	LR	RF
Original dataset	50.19	54.15	57.74	59.15
GR	26.54	38.7	39.38	42.78
DE	25.61	47.47	48.16	51.19
Proposed GRDEFS	4.68	19.52	20.27	24.79





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Table 10: False Discovery Rate (in %) obtained by the Proposed LR-SVM-MC, SVM and RF classification methods using feature selection processed datasets

Feature Selection Techniques	False Discovery Rate (in %) by Classification Methods			
	Proposed LR-SVM-MC	SVM	LR	RF
Original dataset	42.15	49.47	51.23	54.19
GR	11.2	18.27	20.74	30.69
DE	16.32	20.53	28.87	32.59
Proposed GRDEFS	4.28	14.58	17.43	21.48

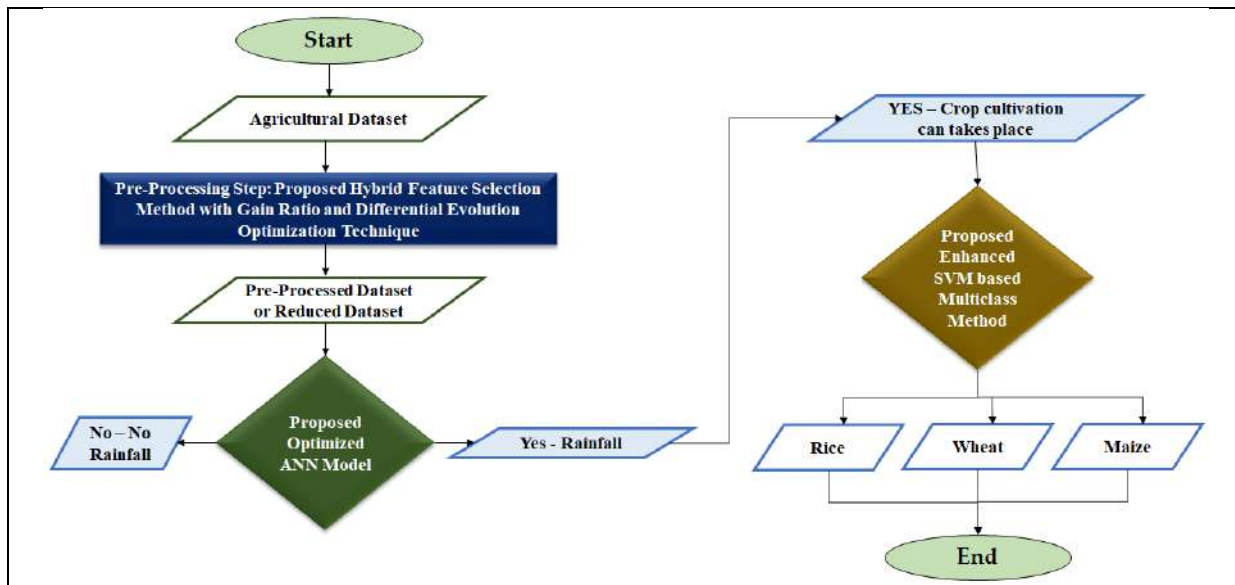


Figure 1: Proposed Framework for the Crop Type Prediction using Machine Learning Methods





Early Diagnosis of Type II Diabetes Prediction on Real Time Data Using Machine Learning Algorithm

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ABSTRACT

From a global health perspective, Type II Diabetes is emerging as an ever increasing challenge: it has almost reached epidemic proportions and its complications constitute one of the important causes of mortality for deaths in European countries. An early diagnosis is very important for a better management of the problem and to prevent further complications in health. The research demonstrated in this paper deals with early detection of Type II Diabetes, [sic] using real time data and classification algorithm (namely Random Forest). We use Random Forest a robust and accurate algorithm, to predict the high-risk of an individual by biomedical markers as well lifestyle factors. The model is thoroughly tested with k-fold cross-validation to make an unbiased and better generalizer by dividing the dataset into various subsets. The study uses a large real-time dataset that covers numerous variables like blood glucose, body mass index (BMI), age, high/low blood pressure and family history of diabetes. The Random Forest algorithm takes the approach of ensemble learning in which it forms multiple decision trees and compile their predictions to increase accuracy with a decrease over fitting. Running a k-fold cross-validation helps even more in making our model reliable by taking averages of multiple evaluation metrics after training the model on various splits, thereby ensuring an unbiased evaluation of how good or bad your algorithm will generalize. The results indicate that the Random Forest classifier performs a good prediction on real time data for predicting Type II Diabetes with F1, Sensitivity and Specificity up to almost 90% in each case. The model was found to be adequately reliable for early detection of LD (Table), based on its



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performance indicators, which include precision and recall as well mean area under receiver operating characteristic curve.

Keywords: Machine Learning, Random Forest, Diabetes, Health care, K-fold, BMI.

INTRODUCTION

Type II Diabetes Mellitus is diagnosed as an impaired tissue sensitivity/insulin resistance to insulin and the lack of ability by B cells in secreting more insulin sufficient enough for preventing hyperglycemia. Factors such as aging populations, unhealthy diets combined with a rise in obesity and physical inactivity have ensured that globally the incidence of Type II diabetes is going up. This has made it a major public health issue, now with serious consequences such as cardiovascular disease; kidney failure neuropathies and retinopathies. Early diagnosis and intervention in these cases is essential to prevent these complications, improve patient outcomes and reduce the burden on healthcare systems metrics. Traditional way for diagnosing Type II Diabetes are clinical examination in addition to blood tests followed by which the disease is usually caught at a stage when it has come long-way into progression. Yet as we continue to improve the utility of prediction models within data science and machine learning; there are increasing efforts for modeling patient populations that have not yet displayed clinically-significant symptoms from developing Type II Diabetes. In turn, models like this could greatly assist in the transformation of preventative care by allowing early intervention and individualized medicine.

This research work is intended to build a real time data based predictive model for early identification of Type II Diabetes using Random Forest classification technique.... Given this large and high-dimensional dataset, the ensemble method Random Forest can be a good choice as well because of its robustness to overfitting (large amount features) yet still able to capture complex interactions between variables. Aggregating and analyzing data from real-time sources including biomedical markers, contextual lifestyle factors and demographic information to uncover patterns that correlate with increased risk of developing Type II Diabetes. Using k-fold cross-validation is a primary evaluation technique in the study to ensure that the predictive model not only can be applied on an unseen set of data, but also perform better than random guess. K-fold cross-validation splits the dataset in K subsets and trains on k-1 of these subsets while evaluating the model other remaining one. This is done k times and each fold will be used as a test once, the results are then averaged to give an accurate estimate of how well the model will perform on unseen samples. This way the model not only is less prone to overfitting, it also ensures that its predictive accuracy remains more or less consistent across different subsets of data. This paper covers the application of Random Forest classification for predicting onset of Type II diabetes in real-time and concentrate on early identification among at-risk patients. The intent of the study is to strengthen approaches for more accurate, sensitive and timely diagnostic tools in diagnosis management of Type II Diabetes by coupling contemporary machine learning methods with robust ade quant evaluation.

These results contribute significantly to predictive analytics in health care, specifically for early detection of Type II Diabetes:

- This work outlines an approach to design a new predictive model for the early diagnosis of Type II Diabetes based on real-time information and Random Forest classification technique. The model integrates broadly-based biomedical, lifestyle and demographic variables to provide a full systems analysis capable of identifying at-risk individuals prior to the onset of clinical symptom.
- The study demonstrates that the Random Forest algorithm is suitable for high-dimensional data, and can pick up non-linear interactions between variables.
- The effectiveness of the model is evaluated using k-fold cross-validation which ensures that it perform robustly on any set new unseen samples.



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- The predictive model with real-time data contributes most eminently, by providing a more interactive and dynamic risk evaluation.
- The research however also is of relevance to the wider field of preventive healthcare, in as much as it supplies a method for both experts and (potentially) patients themselves to identify those at high risk before Type II Diabetes appears with all its very obvious symptoms.

LITERATURE SURVEY

An especially important research focus has been on the early detection of Type II Diabetes with many data sources and predictive models investigated to improve the accuracy and timeliness of diagnosis. This literature review follows the progression of work in this area, taking into account both machine learning methodologies (Random Forest classification), and incorporating real time data into predictor models. Numerous machine learning techniques have been used for predicting the onset of type 2 diabetes from various related input variables, these include classifiers such as support vector machines (SVM), decision trees and neural networks amongst others alongside ensemble-based models like Random Forest. Research by Xing *et al.* (2019) which compared various classifiers and concluded that Random Forest is superior e.g., in terms of accuracy, but also robustness for large or at least more complex data. Pima Indian Diabetes Dataset (PIDD) is widely employed in many studies as a benchmark which observed Random Forest exceeding desirable metric of Precision and Recall i.e. Efficiency to predict diabetes.

Introduced by Breiman (2001), the Random Forest algorithm is an ensemble learning method that constructs a collection of decision trees during training and outputs the mode or mean prediction of the individual trees. Studies such as Zhang *et al.* Random Forest's appropriateness with respect to medical data and its capability for higher-dimensional feature spaces other than the ability of capturing interactions has specifically been pointed out by Chen *et al.* (2020). Research by López *et al.* Recently McKinzie *et al.*, (2021) confirmed that feature selection techniques also improves the performance of Random Forest in diabetes prediction, and they improve its false positive rate by reducing model complexity. Efforts have also been made to incorporate real-time data into the prediction models for Type II Diabetes to help increase accuracy of predictions in assessing research misconception by health services and policy researchers. Mujumdar and Vaidehi (2017) contributed to the development of diabetes prediction models by using real-time electronic health records (EHRs) although their main focus remained static data sources. Studies, such as Choi *et al.* (2008), have also used RMT technology like continuous glucose monitoring (CGM), and practical sensors to offer a more accurate prediction of diabetes in real-time.

K-fold cross-validation has been widely used for the evaluation of predictive models, to ensure robustness in performance metrics. Kohavi [8] emphasized that using k- fold cross-validation to evaluate machine learning models is a general practice, which diminishes bias and variance introduced by the data in model estimation. Patel *et al.* (2019), in the domain of diabetes prediction also validated their Random Forest model using 10-fold cross-validation, which allowed them to reproduce and generalize the results across different data partitions. The method has been very successful in sparse data situations where the risk of over-fitting is important. Random Forest also ranked well in comparison with other machine learning methods for predicting diabetes from clinical data. For example, Alghamdi *et al.* In an empirical comparison, Krompaß and Weidlich (2020) evaluated the performance of Random Forest to Logistic Regression, SVMs/SVCs, GBMs : Gradient Boosting Machines for this scenario indicating that Random Forest is a robust trade-off among interpretable model. Hyperparameter tuning and feature engineering, as well are found to improve the performance of Random Forests immensely, a fact experimentally proven by study conducted by Rahman *et al.* (2021) in which the number of trees and the depth were optimizing to increased model accuracy. Even though the Random Forest method and real-time data integration has been successful in our diabetes prediction, many challenges still persist. Such challenges include inadequate broad data to thrive on population-wide variation and uncertainty, a classic hallmark of studies in personalized medicine; together with difficulties regarding even the more restricted genomic datatypes encompassing subjective lifestyle measures. The possible future research





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as suggested by Zhou *et al.* (2022), should develop more intelligible models for not only forecasting time-to-diabetes but also underlying risk factors to guide demographic specific prevention strategies,

Proposed Work

By developing a novel approach to the problem of early diagnosis with real-time data and using Random Forest classifier classifies tests results for Type II Diabetes, validated by k-fold cross-validation this work provides several important contributions to healthcare analytics. Here we present a fresh idea for diabetes prediction by using the real-time data, which is up to-date biomedical and life-style information. In contrast to traditional models that require static datasets, this research shows how real-time data can enhance the accuracy and timeliness of predictions in a continuously changing environment. Machine learning based framework is proposed and developed to predict T-IIDM with the help of lifestyle indicators. The procedural flow from data acquisition to experimental results is depicted in the framework presented by Figure 1.

We employ an ensemble learning framework to provide better predictions of T2DM based on the lifestyle indicators. Sequentially steps which were performed for the development of framework Canvas:

- Initially we imported Type 2 diabetes mellitus dataset from database into Jupyter Notebook using Python programming.
- We have applied the preprocessing techniques to verify the missing values, outliers, corrupted and inconsistent data samples if any.
- The data is being split into training and testing datasets in the ratio of 75% of dataset to train different EL models, while other 25% was used for validation.
- We have used 10-fold cross validation to validate the accuracy of all classifiers.
- This paper compares a number of statistical measurements such as, accuracy, precision, recall and F1-score etc to identify the optimal EL model for T2DM prediction.

Pre-Processing

Data pre-processing is an essential step in any machine learning model development where the raw data gets transformed into a more appropriate format which can be used by different algorithms. This phase guarantees that the data is consistent, tidy and suitable for analysis.

Data Cleaning

Data cleaning Dealing with missing values, outliers and data inconsistency

Handling Missing Values

Missing data may be addressed by either imputing the missing values or removing them. Imputation methods use mathematical approaches to approximate and complete missing data.

Mean Imputation

If a feature x_j has missing values, they may be substituted with the average of the available values.

$$x'_{i,j} = \frac{1}{N_j} \sum_{i=1}^{N_j} x_{i,j} \quad \forall i \text{ where } x_{i,j} \text{ is missing} \quad (1)$$

N_j is the count of observations that are not missing for feature j .

Outlier Detection

Outliers are exceptional data points that have the potential to skew analytical results.

Z-Score method

To standardize data and detect outliers, we might consider values that deviate from the mean μ by a specific number of standard deviations σ .





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$$z_{i,j} = \frac{x_{i,j} - \mu_j}{\sigma_j} \quad (2)$$

An outlier is typically defined as $|z_{i,j}| > 3$.

Interquartile Range (IQR) Method

An outlier is defined as a number that falls beyond the range determined by the first quartile Q_1 and the third quartile Q_3 .

$$IQR = Q_3 - Q_1 \quad (3)$$

Outliers are values outside $[Q_1 - 1.5 \times IQR, Q_3 + 1.5 \times IQR]$

Feature Extraction and Selection

In this paper, we make an attempt to build effective and accurate Type II Diabetes prediction model that can predict using real-time data by feature extraction and selection. Such techniques can reduce dimensionality, help the model learn better and make sure we use only those features that are most important for a prediction. Central to these routines is the construction of a predictive model, and as such mathematical algorithms like PCA (Principal Component Analysis), mutual information, RFE based feature selection or Lasso must be performed prior this task so that it results in a performant & interpretable predictive model.

Filter Methods

Filter approaches use statistical metrics to rank attributes and then choose the most significant ones.

Mutual Information

Mutual information quantifies the level of interdependence between two variables. Feature X_j and target are defined as follows:

$$I(X_j, Y) = \sum_{x_j \in X_j} \sum_{y \in Y} p(x_j, y) \log \frac{p(x_j, y)}{p(x_j)p(y)} \quad (4)$$

Variables with more mutual information have a stronger predictive power for the target variable.

Chi-Square Test

The chi-square test may be used to evaluate the independence between category characteristics and the target variable.

$$\chi^2 = \frac{(O_i - E_i)^2}{E_i} \quad (5)$$

O_i and E_i represent the observed and predicted frequencies, respectively.

Feature Selection

Recursive Feature Elimination (RFE)

RFE (Recursive Feature Elimination) is a method that iteratively eliminates the least significant features by considering the coefficients of the model. The RFE algorithm proceeds as follows for a model $f(x)$ with features $X = \{X_1, X_2, \dots, X_p\}$:

- Train the model using all the features in the dataset.
- Assign relevance ratings to the features based on their coefficients in linear models and rank them accordingly.
- Eliminate the aspect of least significance.
- Iteratively retrain the model and continue this process until the required number of features is achieved.

Random Forest Feature Importance

Random Forest, an ensemble of decision trees, can compute the importance of each feature based on how much each feature decreases the impurity (Gini index or entropy) in the trees.

For each feature X_j , the importance score $I(X_j)$ is:





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$$I(X_j) = \sum_{t=1}^T [I(G_{before}) - I(G_{after})] \quad (6)$$

Where G_{before} and G_{after} are the Gini indices before and after the split on feature X_j in tree t .

Classification

Various tools and techniques were applied for the implementation of proposed framework, to design the EL models in case on predicting T2DM. An open source software toolkit of Anaconda 2020 and Experimental language is python(3.9.1) along with it IDE used Jupyter Notebook for computation.

Random Forest is a versatile and simple ensemble learning method for classification and regression class methods. It constructs several decision trees and then combines them in order to provide a better prediction than a single tree. Concept of Random Forest Random Forest is Ensemble method and it used multiple Decision Trees to Improve Classification Accuracy. Each tree in the forest is constructed based on a random sample from both data and features, final predictions are an average of all trees (in case of regression) or majority vote for each class (classification task).

Algorithm 1: Early prediction of T-IIDM using RF

Input: Data Collected from people

Output: Prediction of T-II DM

Step 1: Calculate Boot Strap Sampling

Generate m bootstrap samples, D_1, D_2, \dots, D_m , from the original dataset D containing n samples. Each bootstrap sample is created by randomly selecting instances from D with replacement.

Step 2: Select Feature Subset Selection

Randomly choose a subset of k features from the whole collection of p features for each decision tree. This stochasticity aids in decorrelating the trees.

At each node, choose k features from the total p features $\{X_1, X_2, \dots, X_p\}$ in a random manner.

This extract may be designated as:

$$\text{Feature subset at node } j: F_j \subseteq \{X_1, X_2, \dots, X_p\}, \text{ with } |F_j| = k \quad (7)$$

Step 3: Construct the decision tree

For every bootstrap sample D_i and its matching feature subset, construct a decision tree T_i until it reaches its maximum depth (or until a halting requirement is satisfied). The optimal split at each node is found by evaluating a criteria such as Gini impurity or entropy.

Step 4: Calculate the Gini impuriy

At each node t calculate the Gini impurity $G(t)$ for a binary classification task:

$$G(t) = 1 - \sum_{i=1}^C p_i^2 \quad (8)$$

Let p_i represent the percentage of examples belonging to class i at node t , and let C be the total number of classes. The split that is selected is the one that minimizes the weighted average Gini impurity across the child nodes.

$$\Delta G = G(t) - \frac{n_L}{n} G(t_L) + \frac{n_R}{n} G(t_R) \quad (9)$$

Let t_L and t_R represent the left and right child nodes, respectively, and n_L and n_R denote the number of occurrences in each child node.

Step 4: Calculate Entropy (Information Gain)

Entropy at a node t is defined as:





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$$H(t) = -\sum_{i=1}^C p_i \log_2(p_i) \quad (10)$$

Information gain for a split is:

$$\Delta H = H(t) - \frac{n_L}{n} H(t_L) + \frac{n_R}{n} H(t_R) \quad (11)$$

Step 4: Voting

In classification tasks, each tree within the forest contributes to a class vote, and the ultimate prediction is determined by the majority vote. In regression tasks, the predictions are computed by taking the average.

In the classification process, each tree T_i generates a prediction y'_i for a given input x . The ultimate forecast y_i is acquired via a process of majority vote.

$$y' = \text{mode}(y'_1, y'_2, \dots, y'_m) \quad (12)$$

RESULT AND DISCUSSION

Data set Collection

Survey and Google-form based data bases collected from Kishtwar district-Rajouri geographical belt of Jammu & Kashmir, India. Experts like Diabetologists, Endocrinologists for Disease wise selection of parameters have been different; so are the professionals: Dieticians/Nutritionist etc. The dataset has 1978 (987 – non-diabetic and 991–diabetic) instances with a total of T2DM 11 features based on lifestyle properties aiming to maintain health, treat or avoid problems. Table 1 List of the biological features with their Description, Class and Data Type. The data in this study was personal medical history and results from the population of each group. Dataset primary goal The main aim of the dataset used for this study is to be able predict whether a patient will suffer from diabetes or not, based on some lifestyle indicators with machine learning. Based on the Asides the selected features provided in the dataset, it predict as well that are possible patients and how positive they might be of having this disease. Also dataset which have used is good composition of the patients includes people from different location, male female ratio patents in class (Urban and Ruler) all age groups including adults. The dataset were collected with survey and google forms prepared in csv file to perform the prediction of T-II DM through different models forest model for this. The dataset description is used to compute several descriptive statistical measures of the dataset. The describe() function of a Data Frame [160] is used to provide a comprehensive summary of the dataset's parameters. Table 2 displays the calculation of statistical metrics such as count, mean, standard deviation, minimum, percentile, maximum, and other numerical values for the Data Frame.

Performance Analysis

When assessing the performance of a Classification task, many metrics may be used based on the unique objectives and kinds of tasks, such as classification, segmentation, and object identification. Below are some of the parameters utilized for performance metrics:

Accuracy: The accuracy is defined as the proportion of properly identified photos to the total number of images.

$$\text{Accuracy} = \frac{\text{True positives} + \text{True Negatives}}{\text{Total samples}} \quad (13)$$

Precision: The precision is defined as the number of true positive predictions divided by the total number of positive predictions.

$$\text{Precision} = \frac{\text{True positives}}{\text{True Positives} + \text{False Positives}} \quad (14)$$

Recall: The accuracy is defined as the proportion of accurately predicted positive observations to the total number of observations in the actual class.

$$\text{Recall} = \frac{\text{True positives}}{\text{True Positives} + \text{False Negatives}} \quad (15)$$

F-1 score: The harmonic mean of Precision and Recall is calculated by taking the reciprocal of the arithmetic mean of their reciprocals.





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$$F1 - Score = 2X \frac{Precision \times Recall}{Precision + Recall} \quad (16)$$

Histogram Plot for data in Table 2:

Histogram is an instrument for visualization used in case the data comes from some groups. Continuous/discrete variable distribution in an interval of time. Data is plotted and kept contained in sections called bins; this is done using a histogram. Histograms can be used to display the underlying distribution of frequency such as normal distributions, skewness and outliers etc. Figure 3: Histogram contains all the attributes with their distribution.

Performance analysis of the proposed work, simply displayed in figure 4. Based on the confusion matrix, it can be said that the model has successfully predicted 900 non diabetic patients (True Negative) and predict Diabetic of 800 patient, True positive also shows very good overall performance. But it incorrectly also classified 100 non-diabetic as diabetic (False Positives) which may give rise to unnecessary anxiety and interventions. Worse yet, 178 confirmed diabetic cases (False Negatives) were overlooked as 'healthy', potentially postponing life-saving treatment for many individuals. Although the model provides a good prediction for majority of cases, A large number of false negative represents that there is much room to improvement in order not to leave any diabetic patients untreated from becoming late converters.

The accuracy curve for a Random Forest classifier with 85.7% of the accuracy is shown in Figure 5. This is depicted as the red dashed line threshold of 85.7%, there we can see that the accuracy curve level off so it would be some kind of saturation point in which adding more features decrease, rather than improve model performance. This visualization is very important as it assists you to understand when during your classifier's performance reaches and maintains this level of accuracy. Table 3 presents a comparison of the performance measures (Precision, Recall, F1-Score, Accuracy) between the proposed RF classifier and three other models such as K-SVM, K-NN, and DT. A bar plot comparing these metrics across the 4 model can be visualized as shown in figure 6. Figure 6 Performance metrics (Precision, Recall, F1-Score vs Accuracy) comparison of proposed Random Forest classifier with K-SVM, K-NN and Decision Tree models Overall, the Random Forest model performs better than other models on most metrics including Recall (87.2%), and Accuracy (85.7%). Figure 8 K-SVM, as close to performance with a precision of 81.0% and Accuracy:(83.5%). K-NN and Decision Tree have lower performances across all metrics, with K-NN performing worst of all. Random Forest – A high Recall-Precision balance contributes to an impressive F1-Score of 85.2% reflecting the ability when identifying diabetic cases while limiting false positives and negatives This is what makes it a better performer than the compared models in this scenario of classification task.

CONCLUSION

We carried the research for comparing our proposed Random Forest classifier with three available models: K-SVM, K-NN and Decision Tree in terms of varied performance metrics including Precision, Recall, F1 Score and Accuracy. The results show that for most cases, The Random Forest model outperforms all the classifiers with an outstanding 87.2% Recall and a good 85.7% Accuracy which are both essential in positively identifying individuals as potential early-onset T2D positive persons Of these, K-SVM exhibited the most competitive performance but only slightly under-performed in terms of Precision (81.0%) and Accuracy (83.5%). K-NN and Decision Tree models, however are not the best as they showed worst performance in all metrics with K- K being found unsuitable. Random Forest yielded the highest F1-Score (85.2%) and a good balance of Precision & Recall indicating it can better identify diabetic cases without much losing positive or negatives due to its imbalance in class distribution Procedure, compared to rest models, as illustrated by high specificity score. This balance is crucial in a healthcare setting, where accurate and early diagnosis can have major effects on patient lives. Consequently, according to the results of this study Random Forest classifier appears as more efficient predictor for such classification task providing accurate predictions useful for prevention and management of Type 2 diabetes at early stages.





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Table 1: Features taken for survey

S.No	Parameter	Description	Values	Type
1	Age	Age of the subject in years.	Between 5 to 83	numeric
2	Sex	Gender of the subject	Male 1, Female 0	categorical
3	Family History	Whether any family member of the subject is/was suffering from diabetes	No-0, Yes-1	categorical
4	Smoking	Whether the subject is a smoker or not.	No-0, Yes-1	categorical
5	Drinking	Whether the subject is liquor or non-liquor.	No-0, Yes-1	categorical
6	Thirst	The number of times the subjects drink water in a day/night.	Min-1, Max-15	numeric
7	Urination	How many times the subject passes urine in a day/night.	Min-2, Max-15	numeric
8	Height	Height of the subject in centimeter (cm)	Between 61-185	numeric
9	Weight	Weight of the subject in kilogram (Kg).	Min-15, Max-96	numeric
10	Fatigue	If the subject feels fatigued or not.	No-0, Yes-1	categorical
11	Outcome	If the subject is diabetic or not	Non Diabetic-0, Diabetic-1	categorical

Table 2: Description of Dataset

Parameters	count	mean	std	Min	Max
Age	1978	53.429	15.835	5	83
Sex	1978	0.531	0.499	0	1
Family History	1978	0.362	0.445	0	1
Smoking	1978	0.157	0.354	0	1
Drinking	1978	0.466	0.38	0	1
Thirst	1978	8.125	2.434	1	15
Urination	1978	8.325	3.461	2	15
Height	1978	214.87	33.14	61	185
Weight	1978	87.43	11.481	15	96
Fatigue	1978	0.257	0.461	0	1
Outcome	1978	0.673	0.5	0	1

Table 3: Performance Comparison of Proposed Vs Existing model

Model	Precision	Recall	F1-Score	Accuracy
Random Forest	83.4	87.2	85.2	85.7
K-SVM	81	85	82.9	83.5
K-NN	78.5	82.3	80.3	82
Decision Tree	79.7	84.1	81.8	83





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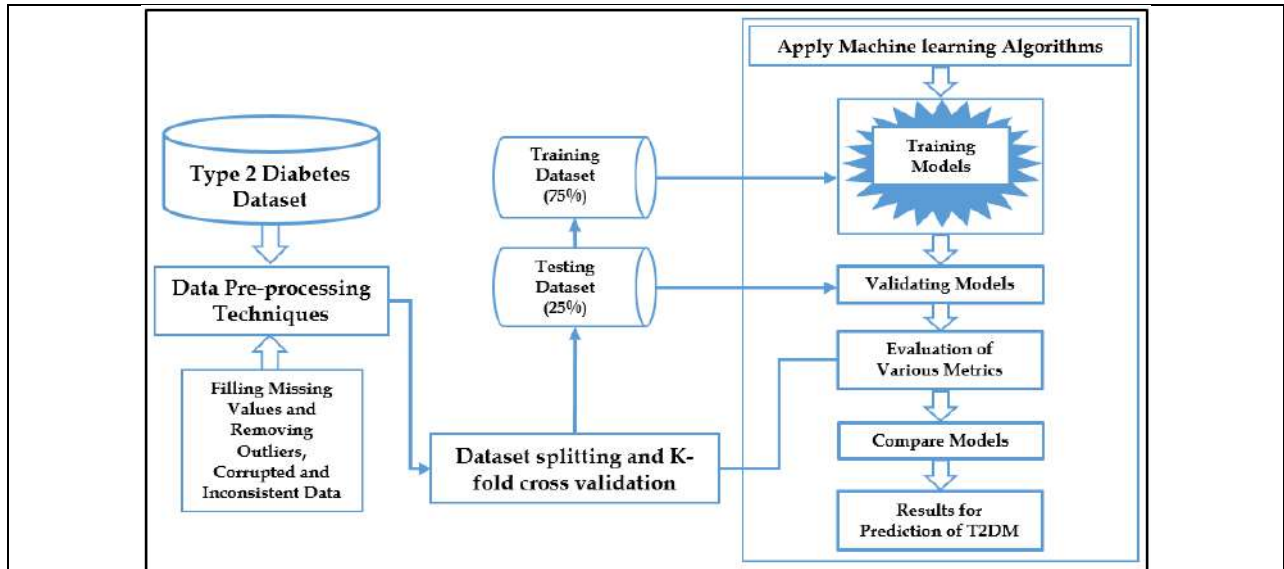


Figure 1: Framework for T-II DM Prediction

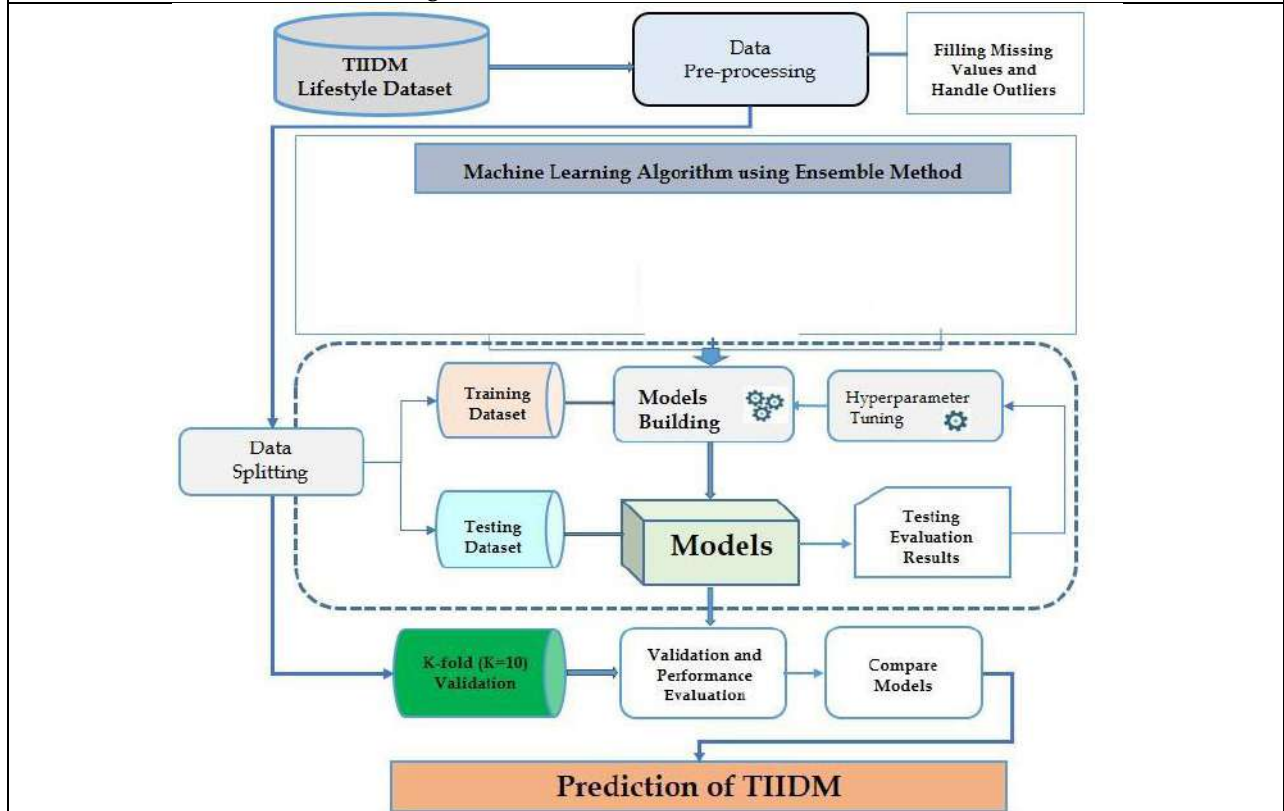


Figure 2: Proposed Frame work for early identification of TII DM





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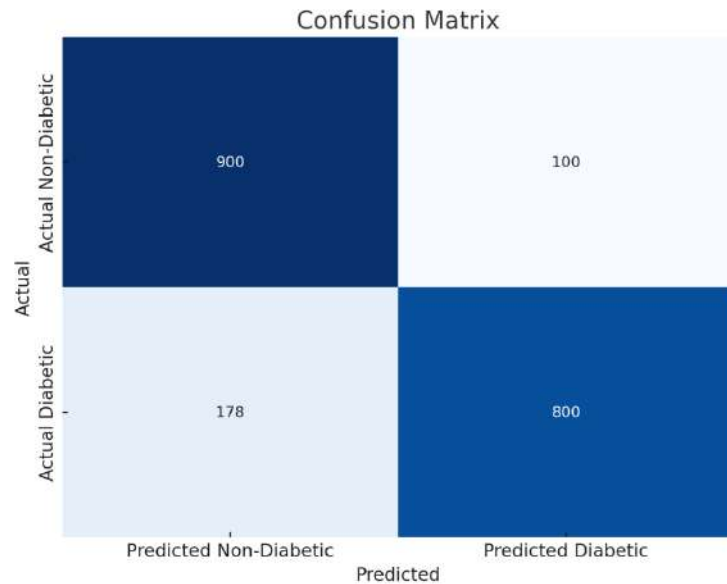


Figure 4: Confusion matrix of proposed work

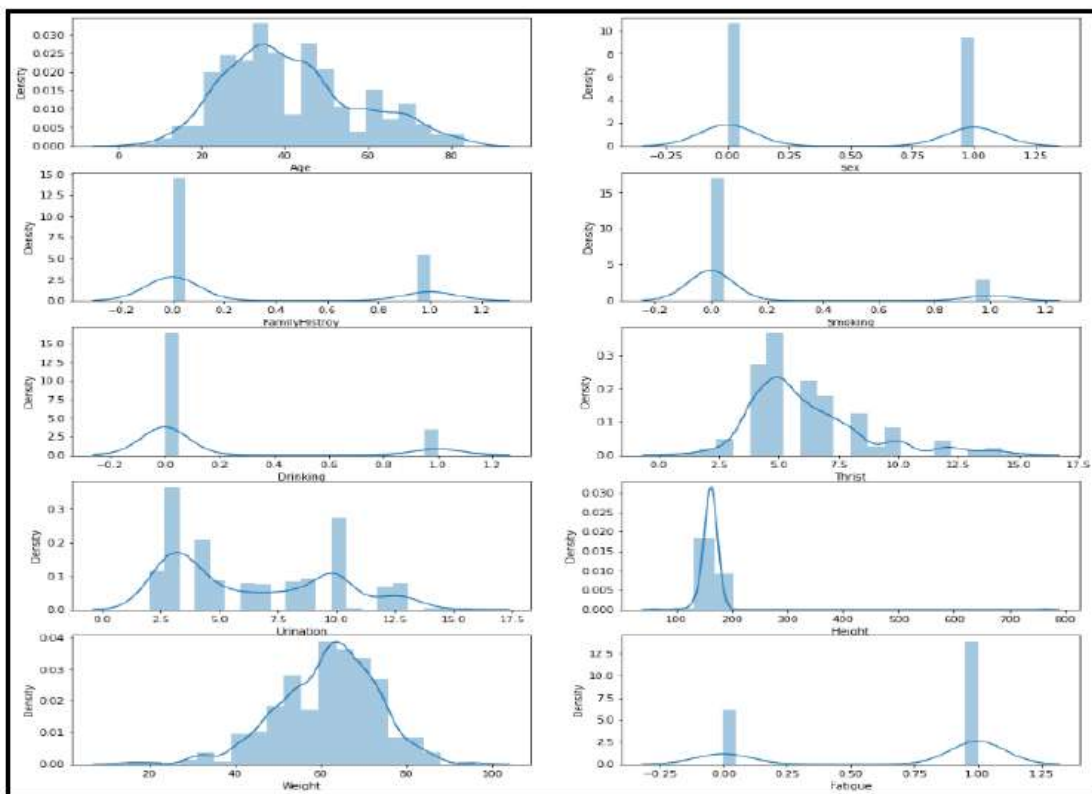


Figure 3: histogram equalization for dataset





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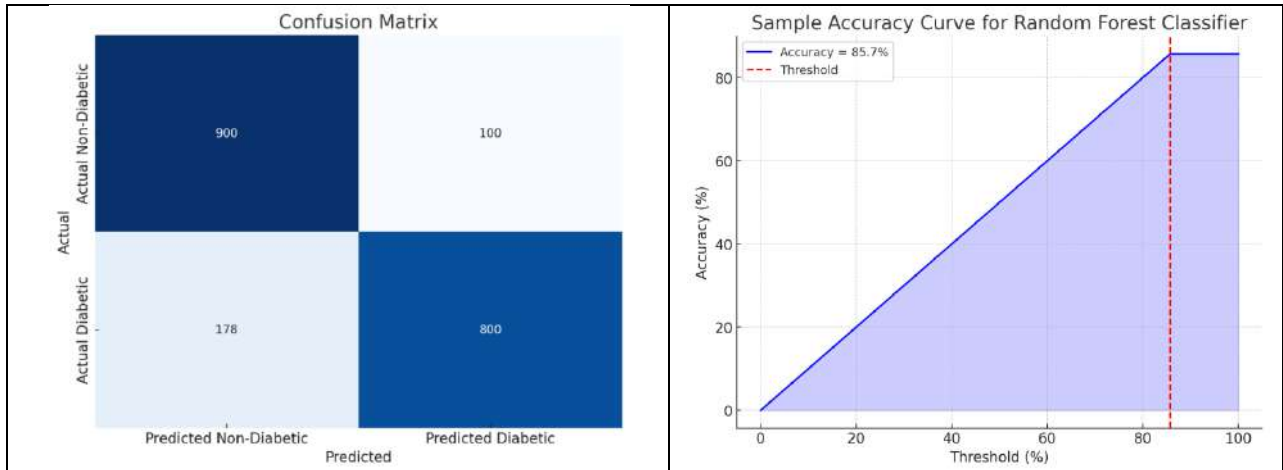


Figure 4: Confusion matrix of proposed work

Figure 5: Accuracy Curve for Proposed Model

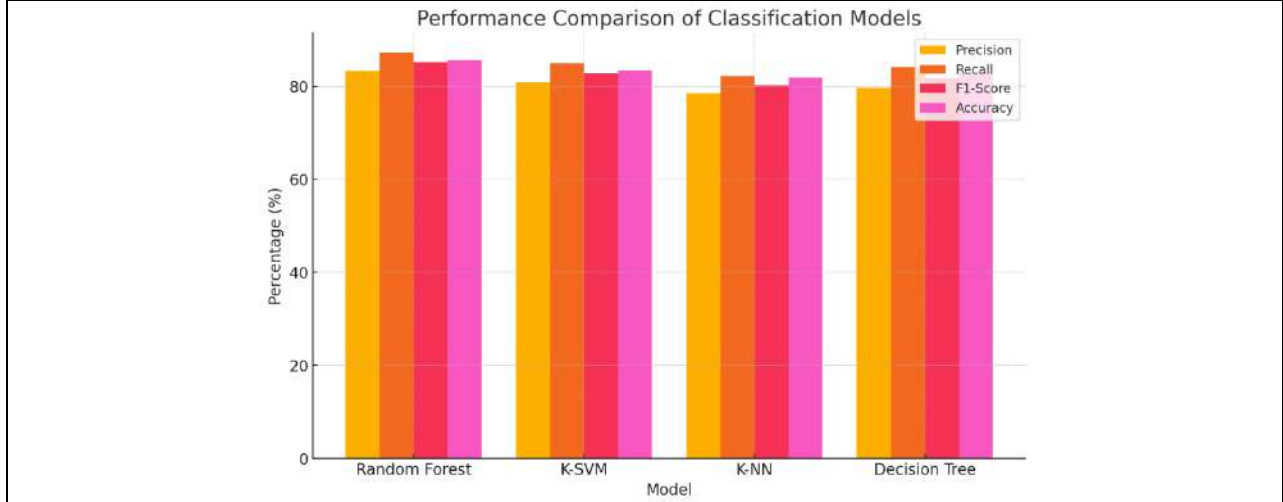


Figure 6: Performance Comparison of proposed work Vs Existing work





Hellinger Divergence Theil–Sen Regression-Based Deep Multilayer Perceptive Feed Forward Network for Predictive Analytics with Big Data

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ABSTRACT

Predictive analytics was the technique with an advanced research approach to find future events, especially in the agriculture field. Agriculture of precision is the leading part within the development of the financial system. Climate as well as soil quality conditions changes have become the most important risk in the prediction of crop yield in agriculture field. But, an accurate prediction faces high complexity. Hellinger divergence matching pursuit Jaspens's correlative regression-based deep multilayer perceptive feed-forward Network (HDMPJCR-DMPFFN) is introduced for increasing accuracy by lesser complexity. Deep feed forward Network includes several layers for processing the given input data. Deep multilayer perceptive network has input layer that collects a large volume of data. Next, input was transformed of deep neural network where the feature selection was performed by Hellinger divergence target matching pursuit. By applying Hellinger divergence, the significant target features related to the prediction are selected. The feature selection helps to reduce complexity time as well as space complexity. Next, selected features were given to subsequent hidden layer to classify the information based on the Multivariate Jaspens's correlative Theil–Sen regression. The regression function detects training features as well as testing features by Multivariate Jaspens's correlation to classify the data for accurate prediction with higher accuracy. Experimental evaluation of HDMPJCR-DMPFFN has various parameters like prediction accuracy, false-positive rate, prediction time, and space complexity. HDMPJCR-DMPFFN enhances accuracy of prediction and decreases the time consumption and space complexity of prediction methods.

Keywords: predictive analytics, big data, Deep feed forward Network, Steepest Hellinger divergence target matching pursuit, Multivariate Jaspens's correlative Theil–Sen regression



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INTRODUCTION

Predictive analyzing has large volume of information for extracting helpful patterns and applicable data that provide future results. Recently, several applications are interested in big data such as Agriculture, healthcare, weather forecasting, and so on. Therefore, big data analytics provides better results in agriculture forecasting for timely and reliable yield prediction. Since the crop yield prediction has soil moisture and weather conditions. In order to achieve this goal, several big data techniques and technologies have been developed to handle and analyze the large volume of data from different resources. An integrated ConvLSTM layer by 3-Dimensional CNN (3DCNN) to crop yield prediction method called 'DeepYield' was introduced in [1] based on correct as well as consistent spatiotemporal feature extraction. But accuracy level of prediction and minimum time consumption was not obtained. An Adaptive Domain Adversarial Neural Network (ADANN) was developed in [2] for accurate prediction. But, designed method was failed for designing feature extractor using more advanced architectures to the well-handled large volume of data. Different machine learning methods were introduced in [3] for forecasting soil moisture. But the key features as well as machine learning scheme was not applied for improving accurate soil moisture prediction. Fuzzy Enumeration Crop Prediction Algorithm (FECPA) was developed in [4] for an efficient crop yield prediction. The designed algorithm decreases the time complexity but the space consumption for accurate crop yield is not performed.

Artificial neural network is developed in [5] to the prediction and improving the performance of Big data analysis and conduct huge quantity of information generated to obtain higher agricultural yield. But, it was unsuccessful failed for focusing better prediction results. Machine learning techniques were introduced in [6] for agriculture by using Big Data. But the processing speed of the data is not increased. Similarity of four machine learning techniques is implemented in [7] for computing the monthly soil temperatures at different intensities. But the techniques failed to work with more data. A deep learning approach was introduced in [8] for crop yield using genotype with climate conditions. An approach failed to perform crop management with the soil data. A deep reinforcement learning technique was developed in [9] for smart agriculture IoT systems. However, the designed technique failed to apply for multitask learning and deep computation for smart agriculture. A crop recommendation system was introduced in [10] that employ Map Reduce with K-means clustering for the prediction of crop yield. However, deep learning scheme is not applied to precise prediction.

Major contributions

The major contribution of HDMPJCR-DMPFFN was described by,

1. A novel technique called HDMPJCR-DMPFFN is developed for big data Prediction with the help of two major processes namely feature selection and classification incorporated into the deep multilayer perceptive feed-forward Network.
2. To decrease the prediction time and space complexity, HDMPJCR-DMPFFN uses the Hellinger divergences target matching pursuit for detecting the significant features for classification process. The matching pursuit projects the relevant features based on divergence estimation. This helps to minimize the memory consumption.
3. To increase the prediction accuracy, Multivariate Jaspens's correlative Theil–Sen regression is applied to the hidden layer of Multivariate Jaspens's correlative Theil–Sen regression. The regression function analyzes the training features and testing features using Multivariate Jaspens's correlation. Based on the correlation, prediction is performed with higher accuracy.
4. Finally, comprehensive experiments are used for estimating quantitative analysis of HDMPJCR-DMPFFN by conventional deep learning on different parameters.

Organization of Paper

The paper was organized by: section 2 provides related works within prediction of big data. Section 3 explains the HDMPJCR-DMPFFN by neat diagram. Section 4 illustrates experimental setup by dataset description. Section 5 gives simulation outcome of dissimilar parameters. Section 6 concludes paper.



**Anita and Shakila****Related works**

Hybrid method termed as crop modeling with machine learning is designed in [11] to provide predictions as well as find a feature over crop modeling. But the time consumption for accurate prediction is not reduced. Machine learning algorithms are introduced in [12] to predict maize yield. The algorithms failed to obtain an accurate prediction. A radar echo prediction scheme was developed in [13] to accurately forecast outline of weather radar echo. However, it failed to perform the long-term forecast to obtain detailed information. Integration of machine learning as well as deep learning was introduced in [14] for forecasting crop yield. But, accuracy estimation remained unaddressed. Machine learning-based random forest (RF) is developed in [15] for predicting cotton yield on different period. But, algorithm failed to use efficient device for forecasting crop yield quicker as well as accurate way. The rainfall prediction scheme was introduced in [16] for prediction on spatial-temporal outline. But, method failed to obtain an accurate prediction with minimum time consumption. Machine-learning techniques were developed in [17] to compute the soil moisture in wheat fields. However, it failed to consider evaluation technique for soil moisture prediction. Multi-temporal deep learning were developed in [18] for accurate performance of large-scale crop mapping. But the important feature selection was not performed. Spatial resolution on quality of crop yield prediction was performed in [19] for site-specific crop management. However, it failed to apply machine learning or deep learning for accurate quality of crop yield. Deep learning regression network (DNNR) was introduced in [20] with big data for a soil moisture prediction. It enhances accuracy but time complexity analysis is not performed.

METHODOLOGY

Big Data prediction is the process of analyzing and extracting valuable data from huge number of structured, semi-structured, as well as unstructured data. Big Data needs tools as well as techniques for identifying with extract patterns over huge-scale data. The increasing nature of Big Data requires enhanced data storage capabilities, higher time, as well as memory consumption. Therefore, feature selection is a dimensionality reduction technique to select the important features for providing accurate predictive results. But, the existing methods failed for increasing performance of accuracy as well as time during prediction process with big data. Deep learning techniques are introduced for enhancing accuracy as well as minimize time. Based on motivation a novel deep learning technique called HDMPJCR-DMPFFN is introduced in this paper. It increases prediction accuracy and time by feature selection and classification. Figure 1 portrays different processes of predictive analytics using HDMPJCR-DMPFFN. The number of features is collected from the dataset. In the first stage, the feature selection process is performed using Hellinger divergensive target matching pursuit to minimize the complexity of prediction. Secondly, the classification process is said to be performed using Multivariate Jansen's correlative Theil-Sen regression. A detailed explanation of the proposed is provided in the following sections.

Deep multilayer perceptive feed-forward Network

The proposed HDMPJCR-DMPFFN technique uses a deep multilayer perceptive feed-forward Network for accurate big data prediction. A deep multilayer perceptive feed-forward network has set of weights for forecast of future. Multilayer feed-forward neural network includes multiple layers. From figure 3, deep multilayer perceptive feed-forward Network was explained. Figure 2 depicts the deep multilayer perceptive feed-forward Network. The structure comprises multiple layers and the neurons like the nodes. Input layer and weighted are transferred concurrently towards the second layer, called a hidden layer. Hidden layer units are given to input to another hidden layer. A hidden layer is chosen based on processes of technique. Weighted outputs of final hidden layer were given to input of the output layer produces the output. Therefore, output of one layer was completely linked to the subsequent forward layer. Hence it is called as feed-forward neural network. Neuron input is generally created as a linear combination of its incoming input values.





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$$I_i(l) = \sum_i \alpha_i^l x_i^l + \varphi_i^l \quad (1)$$

Where, the neuron input ' $I_i(l)$ ' is generally constructed as a linear combination of its incoming input values ' x_i^l ' and corresponding to the weight of the connection ' α_i^l ' at layer ' l ', ' φ_i^l ' denotes bias that stored the value is ' 1 '. Input was transmitted within initial hidden layer.

Hellinger divergensive target matching pursuit

Big data has the demanding task of machine learning and data mining because the dataset comprises a large volume of data. Feature selection was defined as procedure of attaining the subset over original feature to specific measure by removing the redundant and irrelevant features. Therefore a feature selection process improves the learning accuracy and decreases the time complexity. Based on motivation, the proposed technique introduces a Hellinger divergensive target matching pursuit is a dimensionality reduction technique that helps to find the best matching features from high dimensional to low dimensional space. The target matching pursuit uses the Hellinger divergence for identifying the efficient features.

Figure 3 depicts the block diagram of Hellinger divergensive target matching pursuit for relevant features taken from the dataset the given dataset is $k_1, k_2, k_3, \dots, k_n$ is distributed in the given dimensional space. By applying the Hellinger divergence, the distance is measured between the features.

$$H_D = \frac{1}{\sqrt{2}} \|k_i - k_j\| \quad (2)$$

From the (2), H_D denotes a Hellinger divergence of two features ' k_i, k_j '. Then the threshold function was employed for identifying minimum divergence among features. Therefore, the projection is formulated as given below,

$$Y = \begin{cases} H_D > T ; \text{irrelevant features} \\ H_D < T ; \text{relevant features} \end{cases} \quad (3)$$

Where, Y denotes an output function, H_D denotes a Hellinger divergence, T denotes a threshold. The more divergent features are said to be irrelevant. Otherwise, the feature is said to be a relevant feature. In other words, the divergence is lesser than the threshold said to be relevant. Otherwise, the feature is said to be irrelevant. Followed by this, two distinct categories are generated by employing the threshold function for Hellinger divergence. This is owing to the reason that redundant features associated with other features have to be eliminated. The minimum divergence is selected as a relevant feature. Otherwise, the feature is said to be irrelevant. The relevant features are selected for prediction as well as eliminate irrelevant features. Relevant features were projected over high-dimensional space into low-dimensional space.

$$\varphi : k_R(h) \rightarrow \delta_s \quad (4)$$

Where, φ indicates a projection function to project the relevant features from the high dimensional space ' $k_R(h)$ ' into the subset ' δ_s ' in low dimensional space. With this computationally efficient and relevant features were chosen to prediction for minimizing time complexity and maximize accuracy.

Multivariate Jaspens's correlative Theil–Sen regression

After the feature selection, the prediction is performed in the second hidden layer of the deep multilayer perceptive feed-forward Network. HDMPJCR-DMPFFN employs Theil–Sen regression function to detect training as well as testing information on Multivariate Jaspens's correlation function. Here the multivariate represents the correlation is measured based on the number of testing and training features. The Theil–Sen regression is a machine learning technique for estimating the relationships between one or more variables (called 'features'). The main aim of regression analysis is used to predict similar types of data with a specific mathematical criterion. The mathematical criterion is performed using Jaspens's correlation function.





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Figure 4 demonstrates the block diagram of the Multivariate Jaspens's correlative Theil–Sen regression to analyze the given input training and testing data based on the correlation. The input training data $D_1, D_2, D_3, \dots, D_n$ are data collected from the dataset. Then the Multivariate Jaspens's correlation is measured as given below,

$$\rho = \frac{n \sum D_t * D_r - (\sum D_t)(\sum D_r)}{\sqrt{[n \sum D_t^2 - (\sum D_t)^2][n \sum D_r^2 - (\sum D_r)^2]}} \tag{5}$$

From (5), ρ denotes Jaspens's correlation coefficient. 'n' represents a number of data. $\sum D_t * D_r$ denotes a product of paired score of two data. D_t^2 denotes a squared score of D_t and D_r^2 denotes a squared score of D_r . The correlation coefficient provides the resultant value from "-1" to +1. If coefficient provides '+1', then the positive correlation and it provides '-1' provides a negative correlation between two data. Based on the correlation measure, the big data prediction is performed with higher accuracy. Hence, hidden layer is computed by,

$$R(t)^l = [\sum_i \alpha_i^l x_i^l + \varphi_i^l] + [\alpha_{ih}^l * r_i^{l-1}] \tag{6}$$

Where, ' $R(t)^l$ ' denotes the hidden layer result, ' α_{ih}^l ' denotes the weight among input as well as hidden layer, ' r_i^{l-1} ' indicates preceding hidden layer. Finally, hidden layer output was sent to output layer. It is expressed as follows,

$$Z(t) = [\alpha_{no}^l * R(t)^l] \tag{7}$$

From equation (7), ' $Z(t)$ ' denotes the output layer result, ' α_{no}^l ' represents the weight among hidden as well as output layer, ' $R(t)^l$ ' indicates previous hidden layer. Data is properly predicted within different classes. Algorithmic description of the proposed HDMPJCR-DMPFFN is explained below,

// Algorithm 1: Hellinger divergenced matching pursuit Jaspens's correlative regression-based deep multilayer perceptive feed-forward Network

Input: Dataset, Number of features $k_1, k_2, k_3, \dots, k_n$, Number of data $D_1, D_2, D_3, \dots, D_n$

Output: Increase the prediction accuracy

Begin

Step 1: Collect number of features $k_1, k_2, k_3, \dots, k_n$ and data $D_1, D_2, D_3, \dots, D_n$ taken as input at the input layer

Step 2: For each feature // hidden layer 1

Step 3: Measure the divergence ' H_D '

Step 4: if ($H_D < T$) then

Step 5: Feature is said to be a relevant

Step 6: else

Step 7: Feature is said to be an irrelevant

Step 8: end if

Step 9: Select the relevant feature subset

Step 10: Remove the irrelevant features

Step 11: For each training data ' D_i ' with extracted features // hidden layer 2

Step 12: Apply regression function

Step 13: Measure correlation ' ρ ' between training and testing data

Step 14: If ($\rho = +1$) then

Step 15: Data is classified into one class

Step 16: else

Step 17: Data is classified into another class

Step 18: End if

Step 19: Obtain the prediction results at the output layer

Step 20: End for

End





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Algorithm 1 explains big data prediction with higher accuracy. Deep multilayer perceptive feed-forward Network comprises multiple layers for identifying input features. Input layer receives amount of features. Hellinger divergencive target matching pursuit was utilized for identifying relevant and irrelevant features. If divergence is lesser than the thresholds, then the features are projected into a relevant and. Otherwise, the features are projected into an irrelevant subset. With similar feature subsets, the Multivariate Jaspens's correlative Theil–Sen regression is applied in the second hidden layer to perform the prediction. The accurate prediction is performed using the Multivariate Jaspens's correlation. Finally, the correlation output is obtained at the output layer. Depend on analysis, prediction was achieved with minimum time consumption.

Experimental Evaluation

Simulation of HDMPJCR-DMPFFN and Deep Yield [1] ADANN [2] were developed using JAVA by Wazihub Soil Moisture Prediction Challenge are taken from (<https://zindi.africa/competitions/wazihub-soil-moisture-prediction-challenge/data>). This dataset was collected as part of an experiment conducted for over 4 months in 4 fields growing maize and peanuts in Senegal. Dataset is precisely predicted growing maize and peanuts based on soil moisture level, weather conditions in advance. This helps to farmers for preparing the irrigation schedules more efficiently. The IoT soil moisture sensors were set up in each of the maize and peanuts fields and collected the weather station. . The collected agriculture dataset is applied to the deep learning algorithm for training purposes. HDMPJCR-DMPFFN is compared by the outcome obtained over conventional techniques. The dataset comprises following attribute information about the soil, climate conditions of 4 fields of growing two crops namely maize and peanuts in Senegal.

Performance Results Analysis

The performance of the HDMPJCR-DMPFFN and existing Deep Yield [1], ADANN [2] is determined by various numbers of information.

Prediction accuracy: It is referred by proportion of number of data were properly classified to entire amount of input data. It was measured by,

$$Pre_a = \left[\frac{ACd_i}{d_n} \right] * 100 \quad (8)$$

From (8), ' Pre_a ' represents the prediction accuracy, ' ACd_i ' designates the amount of data properly classified and ' d_n ' indicates total amount of data. It was calculated by percentage (%).

False Positive Rate: It was referred by number of data wrongly classified to entire amount of data as input. It was calculated using the formula,

$$FPR = \left[\frac{NICd_i}{d_n} \right] * 100 \quad (9)$$

In (9) ' FPR ' indicates false positive rate, ' $NICd_i$ ' represents number of data incorrectly classified ' d_n ' be the total number of data. FPR was computed by percentage (%).

Prediction time: It was formulated by the number of time consumed for prediction of future results on classification procedure. It is expressed by,

$$T_p = [d_n] * T(d_i) \quad (10)$$

In Where ' T_p ' indicates the prediction time, d_n indicates the number of data and ' $T[d_i]$ ' denotes the time taken for single data. It is calculated by milliseconds (ms).





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Space complexity: It was measured by number of storage necessary with algorithm for achieving big data. It was measured as given below,

$$S_{com} = [d_n] * MS [d_i] \quad (12)$$

Where, ' S_{com} ' indicates space complexity, ' d_n ' denotes number of data and ' $MS [d_i]$ ' indicates memory consumed to single data. It was measured in terms of Megabytes (MB).

As given from table 2, HDMPJCR-DMPFFN is compared with existing methods namely Deep Yield [1] ADANN [2] respectively. The prediction accuracy is measured based on a amount of data ranges of 2500 to 25000. HDMPJCR-DMPFFN achieves higher prediction accuracy upon comparison with the other two existing methods [1] and [2]. This is proved through quantitative analysis. When considering the number of data as 2500, the proposed HDMPJCR-DMPFFN correctly predicts the 2385 data whereas by applying[1] and [2] correctly predicted data are 2200 and 2150 respectively. Thus, prediction accuracy of HDMPJCR-DMPFFN was 95.4% and the prediction accuracy of existing Deep Yield [1] ADANN [2] is 88% and 86% respectively. Followed by which, the different results are observed along with the various input data. Finally, the performance of HDMPJCR-DMPFFN was compared with existing methods. Prediction accuracy of HDMPJCR-DMPFFN was significantly improved as 8% and 11% when compared to Deep Yield [1] ADANN [2]. The graphical representation of prediction accuracy was explained from figure 5.

Figure 5 shows prediction accuracy by 25000 with different amount of data instances collected over soil moisture prediction. As shown in figure 5, the amount of data were taken to horizontal axis as well as performance results of accuracy using three methods are observed on the vertical axis. Accuracy is improved using the proposed HDMPJCR-DMPFFN method when compared to Deep Yield [1] ADANN [2]. This is due to the application of deep multilayer perceptive feed-forward Network uses the Multivariate Jaspens's correlative Theil-Sen regression is applied in the second hidden layer to perform the accurate prediction by analyzing the testing and training data. Lastly, analyzed outcome were detected by output layer. From analysis, an accurate prediction is performed. Table 3 explains false-positive rate with three different methods namely HDMPJCR-DMPFFN, Deep Yield [1], ADANN [2]. False-positive rate is estimated by number of data taken of 2500 to 25000. The obtained results reveal the false positive rate was considerably decreased using HDMPJCR-DMPFFN than existing methods. With consideration of 2500 data to perform experiments. False-positive rate of HDMPJCR-DMPFFN is 4.6% whereas false-positive rate of the Deep Yield [1] ADANN [2] is 12% and 14% respectively. The average of ten observed results indicates that the false-positive rate of HDMPJCR-DMPFFN was decreased as 58% and 65% compared with Deep Yield [1] ADANN [2] respectively. Figure 6 given above illustrates the false positive rate of HDMPJCR-DMPFFN, Deep Yield [1] ADANN [2]. The figure inferred that the HDMPJCR-DMPFFN is comparatively better in terms of providing the lesser false positive rate. This is because of Multivariate Jaspens's correlative Theil-Sen regression for detecting input training data by test information Based on regression analysis, accurate prediction is obtained as well as reduces wrong data at the output layer.

Prediction time using three methods HDMPJCR-DMPFFN,[1], and [2] are reported in table 4 and figure 7 with respect to 25000 samples of data. In the above figure, the horizontal axis represents the number of data instances collected for the dataset and the vertical axis represents the prediction time of three methods. From the graph, the prediction time of HDMPJCR-DMPFFN is relatively lesser than that of Deep Yield [1] and ADANN [2]. Also, the prediction time is increased gradually by amount of data instances increased. Moreover, with the experiment is conducted using 25000 sample data instances, the time consumed for prediction was found to be 15.4ms using HDMPJCR-DMPFFN, 19.6ms using [1] and 22.4ms using [2]. With this result, the prediction time was observed to be minimized using HDMPJCR-DMPFFN. The reason behind the Deep feed forward Network includes several layers for processing the given input data. Deep feed-forward network collects a large volume of data. Input was transformed within initial hidden as feature selection process was carried out using Hellinger divergensive target matching pursuit. By applying the Hellinger divergensive, the target features are selected for prediction hence the proposed technique minimizes the time consumption. Table 5 and figure 8 portrays performance analysis of space



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complexity comparison of three different methods, namely HDMPJCR-DMPFFN, Deep Yield [1] ADANN [2]. Amount of data was considered by input ranges of 2500, 5000, ...25000. Consider the amount of data as 2500 to perform experimentation. The memory consumption for prediction is found to be 15ms using HDMPJCR-DMPFFN whereas the memory consumption of Deep Yield [1] and ADANN [2] were 17.75ms and 20ms. HDMPJCR-DMPFFN attains minimum space complexity than the existing methods. Space complexity of HDMPJCR-DMPFFN was decreased as 12% and 20% compared with existing methods. This is because of applying the target feature selection process before the prediction. Hellinger's divergences target matching pursuit helps to project the significant features and remove the divergent features. This helps to minimize the space consumption for prediction.

CONCLUSION

In this paper, big data prediction is performed in agriculture through the application of HDMPJCR-DMPFFN. The proposed deep learning-based methods are appropriate preferences for evolving the larger data, as they often obtain higher performance of prediction with minimum time consumption. Deep learning technology has made a great fast in the traditional prediction analysis. The integration of a Deep neural Network includes for predictive analysis ensures that the agricultural land for crop prediction is considered based on soil and climate changes. In this work, an HDMPJCR-DMPFFN is first considered as input computationally efficient, and find the target features are selected for robust predictive mining. With the obtained target features, classification is performed by analyzing the testing and training feature for predictive mining with the assistance of Multivariate Jaspens's correlative Theil-Sen regression. Simulation outcome illustrates the performance of HDMPJCR-DMPFFN. HDMPJCR-DMPFFN outperforms current state-of-the-art for agriculture within analyzing the sample data. Also, it is shown that the HDMPJCR-DMPFFN increases the accuracy as well as reduces time, false-positive rate and space complexity than conventional approaches.

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Table 1 Dataset Description

S. No	Feature name	Description
1	Timestamp	Time of recording
2	Soil_humidity_1	Soil humidity of field 1
3	Irrigation_field_1	1 = irrigation on; 0 = irrigation off
4	Soil_humidity_2	Soil humidity of field 2
5	Irrigation_field_2	1 = irrigation on; 0 = irrigation off
6	Soil_humidity_3	Soil humidity of field 3
7	Irrigation_field_3	1 = irrigation on; 0 = irrigation off
8	Soil_humidity_4	Soil humidity of field 4
9	Irrigation_field_4	1 = irrigation on; 0 = irrigation off
10	<u>Air_temperature</u>	The temperature of the air
11	<u>Air_humidity</u>	The temperature of the humidity
12	<u>Air_pressure</u>	Temperature of the pressure
13	<u>Wind_speed</u>	Speed of the wind
14	<u>Wind_gust</u>	Speed of the gust of the wind
15	<u>Wind_direction</u>	Direction of the wind
16	<u>Solar_irradiance</u>	Power per unit area
17	Sun	Radiant energy emitted by the sun
18	Kc	Crop coefficient
19	<u>ETc</u>	<u>Evapotranspiration</u> rate (testing crop)

Table 2 Comparative analysis for Prediction accuracy

Number of data	Prediction accuracy (%)		
	<u>HDMPJCR-DMPFFN</u>	<u>DeepYield</u>	<u>ADANN</u>
2500	95.4	88	86
5000	94	86	84
7500	96	88	86
10000	95	87	84
12500	94.4	86.4	84.8
15000	94.66	87.33	83.33
17500	96	86.85	84
20000	95	90	87.5
22500	95.55	89.77	88.88
25000	94	90.4	87.2





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Table 3 Comparative analysis for false positive rate

Number of data	False positive rate (%)		
	HDMPJCR- DMPFFN	DeepYield	ADANN
2500	4.6	12	14
5000	6	14	16
7500	4	12	14
10000	5	13	16
12500	5.6	13.6	15.2
15000	5.34	12.67	16.67
17500	4	13.15	16
20000	5	10	12.5
22500	4.45	10.23	11.12
25000	6	9.6	12.8

Table 4 Comparative analysis for prediction time

Number of data	Prediction time (ms)		
	HDMPJCR- DMPFFN	DeepYield	ADANN
2500	15.4	19.6	22.4
5000	21.28	25.2	27.44
7500	25.2	29.4	31.92
10000	31.36	35.84	39.2
12500	37.8	40.6	44.8
15000	40.32	47.04	50.4
17500	45.08	50.96	54.88
20000	47.04	53.76	58.24
22500	55.44	57.96	60.48
25000	58.8	61.6	64.4

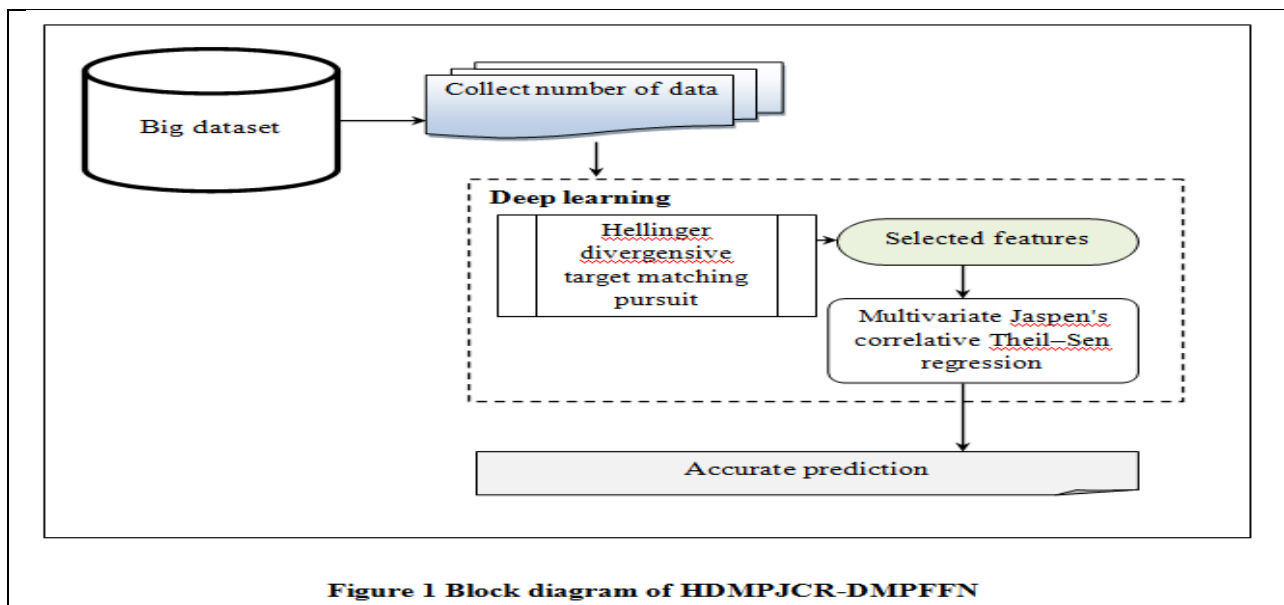




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Table 5 Comparative analysis for space complexity

Number of data	Space complexity (MB)		
	HDMPJCR-DMPFFN	DeepYield	ADANN
2500	15	17.75	20
5000	17.5	22.5	25
7500	26.25	28.875	33.75
10000	30	35	38
12500	32.5	36.25	40
15000	36	43.5	45
17500	39.025	45.5	49
20000	44	46	52
22500	47.25	49.5	54
25000	50	53.75	60



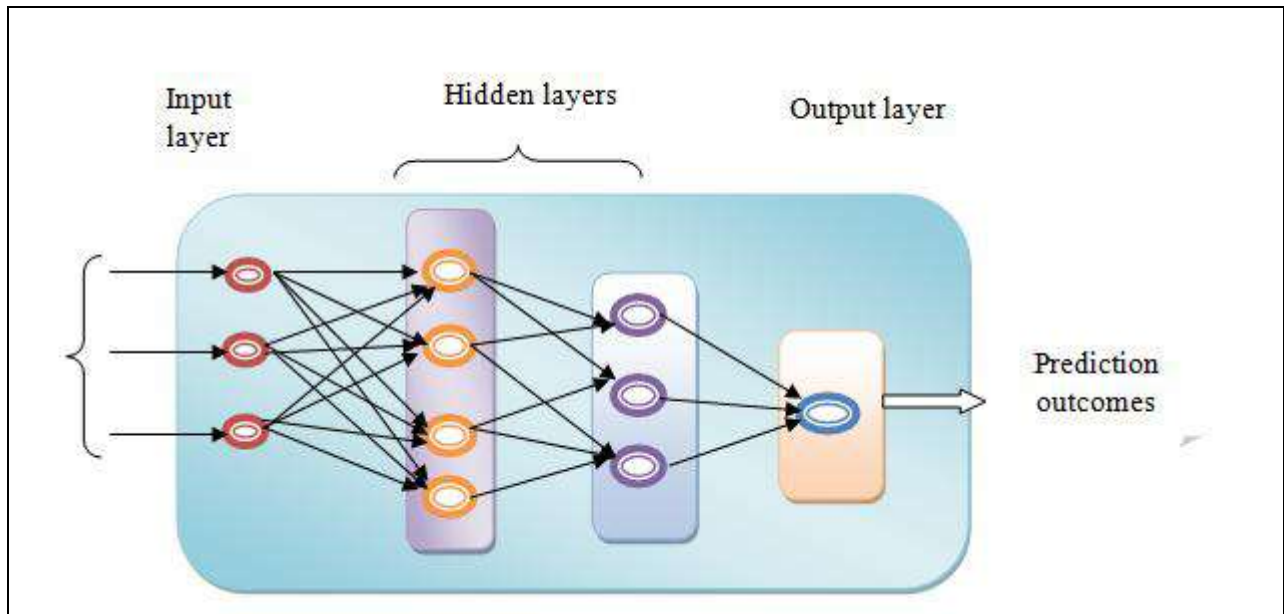


Figure 2 Structure of deep multilayer perceptron feed forward network

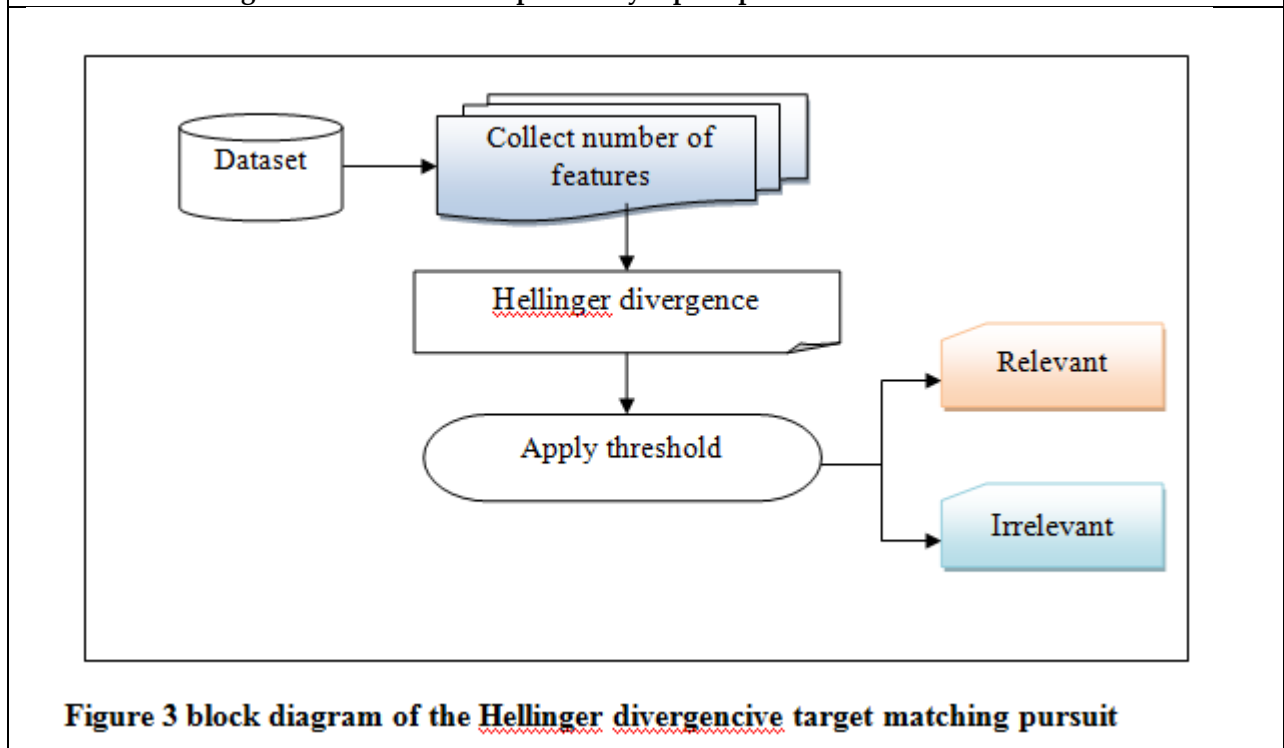


Figure 3 block diagram of the Hellinger divergence target matching pursuit





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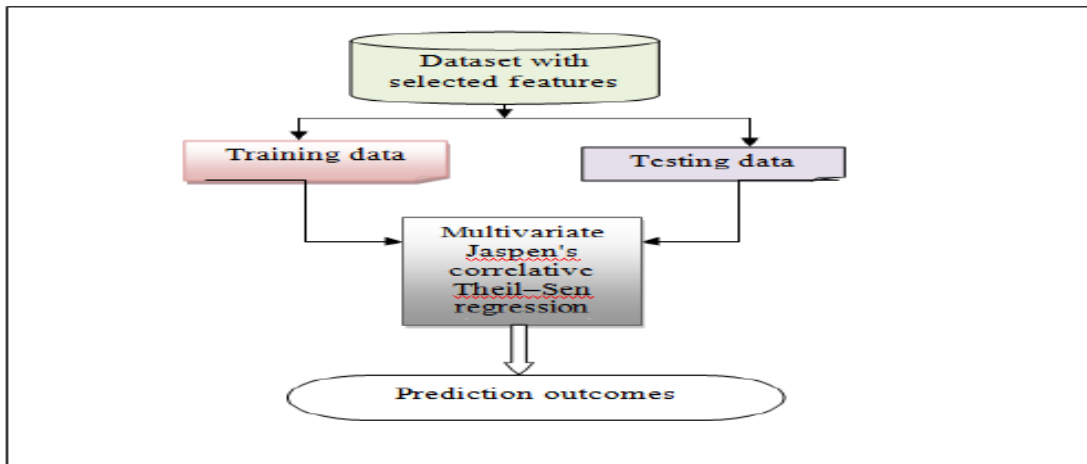


Figure 4 block diagram of Multivariate Jaspren's corrlative Theil-Sen regression

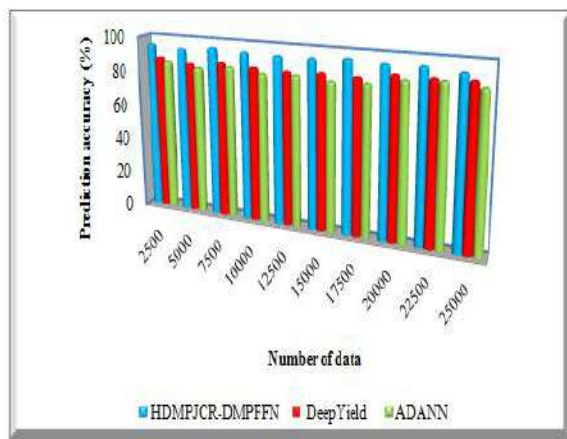


Figure 5 Graphical illustration of prediction accuracy

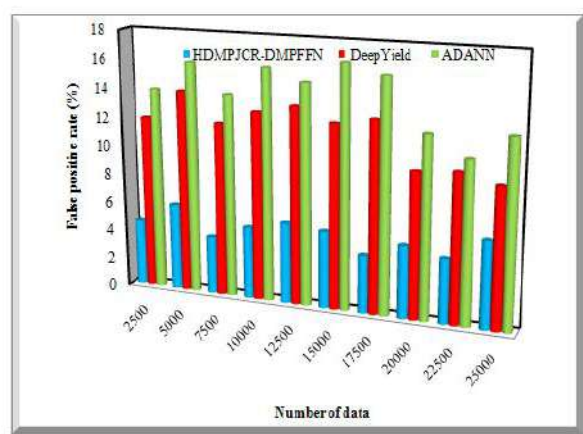


Figure 6 Graphical illustration of false-positive rate

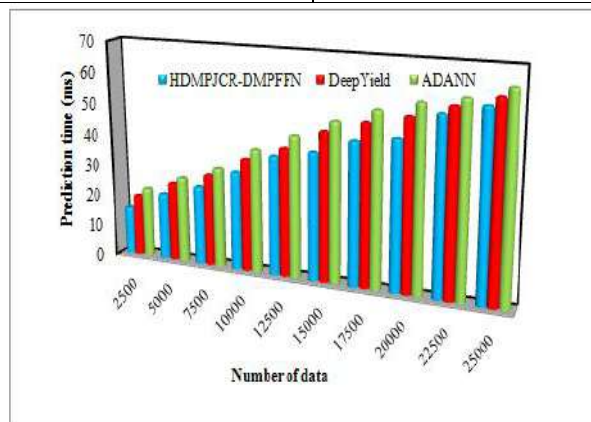


Figure 7 Graphical illustration of Prediction time





Challenges and Future Directions in Blackhole Attack Mitigation in Mobile Ad Hoc Networks

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ABSTRACT

The increasing use of Mobile Ad Hoc Networks (MANETs) in various applications has raised significant concerns about network security due to their decentralized nature, dynamic topology, and limited resources. Among the various threats, the blackhole attack is one of the most critical, where malicious nodes falsely advertise the shortest route to a destination and intercept or drop packets. Detecting and mitigating blackhole attacks have been widely explored in the literature, leading to the development of numerous approaches. This review provides a comprehensive analysis of the existing methods for detecting blackhole attacks in MANETs, including trust-based mechanisms, cryptographic approaches, machine learning techniques, and hybrid solutions. It examines the strengths and limitations of each method, focusing on their effectiveness, computational overhead, and scalability. The review also highlights key research gaps, such as handling multiple coordinated attackers, energy-efficient detection methods, and real-time implementation challenges. Furthermore, it emphasizes the importance of balancing security with the network's performance in resource-constrained environments. This literature review aims to provide researchers with a detailed understanding of the state-of-the-art in blackhole attack detection, guiding future efforts toward more robust, efficient, and scalable security solutions for MANETs.

Keywords: Mobile Ad Hoc Network, Attack Detection, Black Hole Attacks, Intrusion Detection





INTRODUCTION

Mobile Ad Hoc Networks (MANETs) have emerged as a key enabling technology in various fields such as military communication, disaster recovery, emergency rescue operations, and smart vehicular networks [1]. The decentralized nature of MANETs, where nodes communicate without relying on any fixed infrastructure or central authority, allows for quick deployment in environments where traditional networks are impractical. However, the unique characteristics of MANETs, including dynamic topology, limited bandwidth, constrained energy resources, and the absence of centralized control, make them highly vulnerable to a range of security threats. Among these threats, routing attacks are particularly problematic due to their ability to disrupt the fundamental communication processes in the network [2]. One of the most severe routing attacks in MANETs is the blackhole attack. In a blackhole attack, a malicious node advertises itself as having the shortest or optimal path to a specific destination node. Once this malicious node becomes part of the routing process, it drops all or most of the data packets it receives, disrupting the flow of information and causing severe network performance degradation. The distributed and self-organizing nature of MANETs makes detecting such attacks particularly challenging, as there is no central entity to oversee or authenticate the routing process.

The impact of blackhole attacks on MANETs can be devastating. These attacks not only reduce network throughput but also cause significant delays and packet loss, compromising the overall quality of service (QoS) [3]. In critical applications, such as military or emergency response systems, such disruptions can have life-threatening consequences. Therefore, developing effective methods for detecting and mitigating blackhole attacks is essential to ensure secure communication in MANET environments. Over the years, several techniques have been proposed to address the challenge of blackhole attack detection. These techniques can be broadly categorized into trust-based methods, cryptographic schemes, and machine learning approaches. Trust-based methods rely on monitoring node behavior to assess their trustworthiness, whereas cryptographic schemes use encryption and authentication to secure communication paths. Machine learning approaches leverage pattern recognition and data analysis to detect anomalous behavior indicative of a blackhole attack. Some hybrid approaches combine elements from multiple techniques to enhance detection accuracy and efficiency. Despite the significant progress made in this field, several challenges remain. Many detection methods introduce additional computational and energy overhead, which can be detrimental in resource-constrained MANET environments. Moreover, some techniques struggle to adapt to dynamic topologies or fail to handle scenarios with multiple or coordinated attackers. These challenges underscore the need for more advanced and efficient detection mechanisms that can balance security with performance in MANETs [4] [5]. This paper presents a detailed literature review of the existing blackhole attack detection techniques in MANETs. It examines the evolution of detection strategies, highlighting their key features, advantages, and limitations. The review also identifies critical gaps in the current research and suggests directions for future work to address the challenges of blackhole attack detection in MANETs.

Background Study on MANET

Mobile Ad Hoc Networks (MANETs) represent a transformative approach to wireless communication, providing a decentralized, dynamic, and self-configuring network architecture. Unlike traditional networks, MANETs operate without the need for a fixed infrastructure, such as base stations or access points. Each node in a MANET functions both as a host and a router, facilitating multi-hop communication across the network. MANETs are characterized by their ability to form and maintain connectivity autonomously, making them well-suited for a variety of applications in both civilian and military domains.

Architecture of MANET

The architecture of a MANET is characterized by its lack of centralized control or pre-established infrastructure. Instead, each node in the network acts as both a router and an end device, which means that data can be transmitted directly between nodes that are within communication range or relayed through intermediate nodes in a multi-hop fashion. The flexibility and decentralized nature of MANETs allow for rapid deployment in various environments,



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including those where traditional networks may not be feasible or available [1] [2]. In a MANET, nodes are typically mobile devices such as Smartphone, laptops, tablets, or military equipment. These devices are equipped with wireless transceivers, which allow them to communicate over wireless links. Since the topology of a MANET changes frequently due to node mobility, the network must be able to adapt to these changes in real time, maintaining communication and routing functionality even as connections are formed or broken.

The basic building blocks of a MANET include:

Mobile Nodes: Devices that move independently and participate in routing and communication.

Wireless Links: Connections between nodes that enable communication. These links are often unreliable and prone to interference, making robust routing essential.

Routing Protocols: Algorithms used to determine optimal paths for data packets between nodes.

Characteristics of MANET

MANETs possess several unique characteristics that distinguish them from traditional networks:

Decentralized Architecture: MANETs lack a central controlling authority, which means that every node is responsible for routing and forwarding packets. This decentralization offers high flexibility and robustness in dynamic and challenging environments.

Dynamic Topology: The topology of a MANET can change frequently due to node mobility. Nodes may join or leave the network at any time, and connections between nodes may break or re-establish as nodes move in and out of communication range. This mobility-driven dynamic nature poses significant challenges for maintaining consistent and reliable communication.

Multi-Hop Communication: In MANETs, nodes must often rely on intermediate nodes to forward data to the destination, as the source and destination nodes may not always be within direct communication range. This requires sophisticated routing protocols that can handle frequent topology changes.

Limited Resources: MANET nodes typically operate in environments with constrained resources, such as limited battery life, processing power, and bandwidth. As a result, network protocols must be designed to operate efficiently while minimizing resource consumption.

Lack of Centralized Infrastructure: Since MANETs are infrastructure-less, the nodes themselves must handle network management tasks, such as route discovery, route maintenance, and resource allocation. This increases the complexity of network protocols and requires distributed algorithms to ensure network performance and reliability.

Scalability Challenges: MANETs can range from small, localized networks to large-scale networks involving hundreds or even thousands of nodes. As the network grows, maintaining effective communication and managing routing overhead becomes increasingly difficult, posing challenges in scalability.

Routing in MANET

One of the most critical functions in a MANET is the routing process. Due to the lack of centralized control and dynamic topology, efficient and reliable routing is essential for network performance [3] [11] [12]. MANET routing protocols can be broadly classified into three categories:

Proactive Routing Protocols: Also known as table-driven protocols, these protocols maintain up-to-date routing information to all nodes in the network by periodically exchanging control messages. Examples include Destination-Sequenced Distance-Vector (DSDV) and Optimized Link State Routing (OLSR). Proactive protocols aim to reduce route discovery delay but incur overhead due to frequent updates, especially in highly dynamic environments.



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Reactive Routing Protocols: Also known as on-demand protocols, these protocols create routes only when needed by the source node. Examples include Ad hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR). Reactive protocols reduce routing overhead but can introduce delay due to route discovery processes.

Hybrid Routing Protocols: These protocols combine features of both proactive and reactive approaches to balance the trade-offs between routing overhead and delay. One example is the Zone Routing Protocol (ZRP), which uses proactive routing within a local zone and reactive routing outside the zone.

Background Study on Black Hole Attacks in MANETS

Mobile Ad Hoc Networks (MANETs) offer significant advantages in terms of flexibility, ease of deployment, and scalability, making them highly suitable for dynamic, infrastructure-less environments [6] [7]. However, these benefits come at a cost, as MANETs are highly vulnerable to various security threats due to their decentralized nature, dynamic topology, and absence of centralized control mechanisms.

The blackhole attack is one of the most severe routing attacks in MANETs due to its ability to disrupt communication by intercepting and dropping packets.

Blackhole Attack Mechanism

A blackhole attack targets the network layer, specifically the routing protocols, by exploiting the trust that nodes have in the routing information exchanged within the network. In a typical MANET, nodes use reactive routing protocols like the Ad Hoc On-Demand Distance Vector (AODV), which discover routes only when a node has data to send. The route discovery process involves broadcasting route request (RREQ) messages to neighboring nodes, which are propagated throughout the network until the destination is reached or an intermediate node has a valid route to the destination [8] [9] [10].

In a blackhole attack, the malicious node exploits this process by falsely advertising itself as having the shortest or most optimal route to the destination, even though it does not have a valid route. The following steps illustrate how a blackhole attack unfolds:

Route Discovery: When a source node initiates a route discovery process by broadcasting an RREQ, the blackhole node responds with a route reply (RREP) message, claiming it has a direct and optimal path to the destination.

Route Establishment: The source node selects the route advertised by the blackhole node, assuming it to be the most efficient.

Packet Dropping: Once the source node begins sending data through the malicious node, the blackhole node either drops or selectively forwards the packets, leading to data loss and communication disruption.

Types of Blackhole Attacks

Blackhole attacks can be further categorized based on the attacker's behavior:

Single Blackhole Attack: In this scenario, only one malicious node is involved in the attack. It advertises a fake route and drops all incoming packets.

Collaborative Blackhole Attack: Multiple malicious nodes cooperate to form a virtual blackhole. One node advertises the false route, while others assist by dropping or rerouting packets, making detection more challenging.

Impact of Blackhole Attacks on MANETs

The impact of a blackhole attack on MANET performance can be severe. Some of the critical consequences include:

- **Data Loss:** As the malicious node drops or discards packets, legitimate data fails to reach its intended destination, resulting in significant data loss.



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- **Network Congestion:** The attack causes an increase in retransmissions and additional route discovery processes, which can congest the network and consume valuable bandwidth.
- **Degraded Throughput:** With packets being dropped or misrouted, the overall network throughput is reduced, affecting the quality of service (QoS).
- **Increased Latency:** The source node may experience delays in data transmission as it continuously attempts to resend lost packets or initiate new route discoveries.
- **Trust Compromise:** In a collaborative blackhole attack, multiple malicious nodes work together to deceive the network, undermining the trust in legitimate nodes and protocols.

LITERATURE REVIEW

Yazdanypoor, Mohammad, Stefano Cirillo, and Giandomenico Solimando [11] suggested a comprehensive hybrid detection method that markedly improves the identification and mitigation of black hole and grey hole assaults. Our methodology incorporates anomaly detection, sophisticated data mining tools, and cryptographic validation to create a multi-tiered defence system. Comprehensive simulations indicate that the suggested hybrid technique attains enhanced detection accuracy, minimises false positives, and sustains elevated packet delivery ratios, even in the presence of attacks. This technique offers superior reliability and resilience in network performance, dynamically adjusting to emerging threats compared to previous systems. This research signifies a substantial progress in MANET security, providing a scalable and efficient method for protecting essential MANET applications from advanced cyber-attacks. Ramachandran, Dhanagopal, *et al* [12] A black hole node is designed to deceive other access points into believing they must utilise it as their pathway to a certain destination. The black hole node in a cable network is undetectable and irreparable within an AODV network. In this study, we enhanced AODV by employing a lightweight method grounded in time and baiting to identify and differentiate between individual and collaborative black hole attacks. MANETs exhibit a dynamic topology, utilise an open medium, and lack a centralised monitoring point, all of which provide security challenges. Security assaults constitute one category of attacks. In MANETs, there is no central administration, and mobile devices connect to one another wirelessly. Black holes, insider assaults, grey holes, parallel worlds, defective nodes, and packet losses are all hazards that can significantly interrupt secure communication. Simulation results indicate that the suggested method substantially surpasses prior techniques regarding end-to-end delay, throughput, packet delivery ratio, and average energy consumption. Our proposed technique employs a multipath methodology to alleviate the black hole attack in MANET. The suggested technique is evaluated in a simulated environment to assess its stability under attack conditions.

Abdallah, Ashraf Abdelhamid, *et al* [13] The primary objective of this project is to develop a methodology for detecting blackhole attacks using anomaly detection techniques using Support Vector Machines (SVM). Our detection system analyses node activity to examine network traffic for anomalies. In blackhole circumstances, attackers display unique behavioural traits that differentiate them from other nodes. The suggested SVM-based detection method can efficiently identify this. The suggested detection system aims to analyse network data and discover anomalies through the examination of node behaviours. In the context of black hole threats, it differentiates attackers from legitimate nodes based on behavioural traits. This method enables the system to efficiently identify blackhole attacks. The results indicate a high degree of accuracy in detecting blackhole attacks, validating its effectiveness in safeguarding mobile ad hoc networks (MANETs) by identifying and isolating rogue nodes. This method is especially beneficial in contexts such as military operations and crisis management, when a dependable communication system is essential. Mohanraj, Mr K., and B. Arivazhagan [14] Devised a technique for identifying and mitigating black hole attacks in wireless ad hoc networks through fuzzy heuristics. The methodology entails establishing fuzzy logic rules and heuristics to detect anomalous behaviour indicative of black hole assaults within network traffic. Algorithms are formulated to assess network metrics including packet routing, signal strength, and node behaviour through fuzzy logic methodologies. Attack detection algorithms are employed to dynamically modify network parameters utilising fuzzy inference to alleviate the effects of black hole assaults. Anomaly detection



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and prevention modules are incorporated into current network protocols to bolster security against black hole attacks.

Mekadem, Lahcene, and Malika Bourenane [15] Proposed the construction of a cross-layer intrusion detection system to counteract black hole assaults in mobile wireless networks. The suggested methodology has two tiers. At the initial level, data obtained from several layers serves as input to the fuzzy logic system to ascertain the classification of a specific node (malicious, normal, or suspicious). At the secondary level, if a node is deemed suspect, the Dempster-Shafer theory will be utilised to validate that node. Sivanesh, S., and V. R. Sarma Dhulipala [16] Presented the innovative host-based intrusion detection system (HIDS) termed analytical termination of malicious nodes (ATOM), which methodically identifies a prominent black hole attack that impacts the efficacy of the AODV routing protocol. ATOM IDS detects by calculating the RREP count (Route Reply) and the packet drop rate for each node individually. This system has been simulated using the AODV routing protocol integrated with black hole nodes, and the resulting simulation scenario has been produced in NS2. The trace indicates a significant enhancement in the packet delivery ratio (PDR) and throughput. The findings demonstrate the effectiveness of the proposed system.

Shukla, Mukul, and Brijendra Kumar Joshi [17] The suggested solution employs a trust-based fuzzy method that incorporates energy auditing, evaluates the trustworthiness of nearby nodes, verifies packet integrity, and authenticates node members. Trust values in fuzzy logic span from 0 to 1. If the node's trust value is greater than or equal to 0.6, the node is deemed trusted, and its type is utilised for communication between the source and destination in our case. If the node trust rating in the routing table is below 0.6, it indicates that the node is a blackhole node, rendering it an unsafe route. This work proposes a solution called Trust-based Fuzzy Ad hoc On-Demand Distance Vector (TFAODV) to address this attack scenario. Khosa, Thabiso N., Topside E. Mathonsi, and Deon P. Du Plessis [18] The literature assessment indicated that current solutions do not consistently guarantee accurate node classification. The cooperative nature of MANET occasionally results in the erroneous exclusion of innocent nodes and/or the inaccurate classification of malicious nodes. This study proposes a novel Grey Hole Prevention (GRAY-HP) technique for the detection of malicious nodes, achieving a high accuracy rate in node categorisation. The proposed algorithm utilises and adapts the gray-attack prevention method termed Secure Detection Prevention and Elimination Grey Hole (SDPEGH), together with a proactive strategy.

Suma, S., and Bharati Harsoor [19] To distinguish packet loss caused by congestion from that induced by a malicious node, our approach employs an on-demand link and energy-aware dynamic multipath (O-LEADM) routing scheme for mobile ad hoc networks (MANETs) to identify black-hole nodes through the integration of a bait method. The node's behaviour is assessed using control messages, specifically destination-sequence (des-Seq) and reply-sequence (rep-Seq), during channel access. During route discovery, each intermediate node in the network transmits the des-Seq message to all its neighbouring nodes, which subsequently respond to the intermediate node by delivering the rep-Seq message. If the des-Seq and req-Seq from neighbouring nodes do not align, the node is deemed malevolent. Access to the network layer is permitted for an intermediate node if the des-Seq and rep-Seq are congruent. The channel availability and link quality parameters assess link stability, enabling nodes to chose forwarding based on their behaviour and their capacity to achieve Quality of Service (QoS) metrics, including link quality, residual energy, and enhanced packet delivery. Pullagura, Joshua Reginald, and Venkata Rao Dhulipalla [20] examined the detection technique for black hole attacks within the standard ad hoc on-demand distance vector (AODV) routing protocol. The initial phase of the planned work involved a black-hole attack configured on the ordinary AODV protocol. The black-hole node will respond to route requests with the greatest sequence number to incentivise the sender to establish a route through it. The threshold mechanism of the intruder detection system identifies and isolates black-hole nodes. This article estimates the maximal destination sequence number using a linear regression approach. A performance comparison is conducted among standard, black hole-based, and black hole-detection routing systems.

Abdelhamid, Ashraf, *et al* [21] Proposed a solution for identifying black hole assaults utilising anomaly detection with a support vector machine (SVM). This detection system is designed to analyse network data and find anomalies by examining node behaviours. In instances of black hole attacks, the attacking nodes exhibit behavioural traits that



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distinguish them from regular nodes. These attributes can be efficiently identified with our streamlined detection technology. An OMNET++ simulator is employed to assess the efficacy of this method by generating traffic during a black hole attack. Traffic is subsequently categorised into harmful and non-malicious, facilitating the identification of the malicious node. The proposed approach demonstrated exceptional accuracy in identifying black hole attacks. Reddy, Bhaskar, and B. Dhananjaya [22] The intermediate nodes transmit data to the designated destination, considering the necessary locations for accurate delivery. The routing protocol in an Ad hoc network employs nodes to assess various device locations and methodologies for potential data paths before determining the optimal route and methods for data exchange. The anomaly arises from the existing trust among various nodes and the dynamic topology, rendering routing protocols vulnerable to Denial of Service attacks, including black hole and wormhole attacks. The lack of integration into a central infrastructure subjects MANETs to conditions that conventional networks typically mitigate by injecting control packets and monitoring the target's movement once the user is connected to the wireless network. In a MANET, the attacker operates prior to the mark entering the wireless medium. Maliciously exploiting diverse routing information might precipitate further disorder within the system, ultimately resulting in extensive network failure. The current AODV attack, known as the Blackhole attack, operates by deliberately withholding critical routing information from end-users who could have utilised it, precisely as the adversary executes in this scenario. In this situation, the data packets remain undelivered, resulting in complete data loss for the system. The array of detection and protection methods utilised against the blackhole attacker substantially reduces the number of suspects. This article advocates for the inclusion of the OSPFV protocol for wireless LANs, incorporating built-in security through threshold evaluation and cryptographic verification. This paper simulates two protocols, the blackhole attack and the proposed AODV-BS, across various MANET models. It employs two additional network metrics: Network Packet Delivery Ratio and normalised Out of Routing Overhead Utilisation, alongside Network Delay, to analyse their performance and derive conclusions.

Kaushik, Sheetal, *et al* [23] concentrated on the Ad Hoc On-Demand Multi-Path Distance Vector Routing (AOMDV) protocol, favoured for its enhanced efficiency relative to a single-path routing protocol in MANETs. We analyse, examine, and assess the optimisation of routes in wireless ad-hoc networks by minimising packet hops across nodes. This study proposes a unique method, the K-AOMDV protocol, which use K-means clustering to mitigate routing misbehaviour. The efficacy of the proposed K-AOMDV (KNN-Ad-hoc On-Demand Multi-Path Distance Vector) routing protocol is assessed by a supervised machine learning methodology to forecast ideal routes considering latency and security threats. Utilising multiple pathways and dynamic route discovery guarantees reliable data transmission despite the existence of hostile nodes. Srilakshmi, R., and Jayabhaskar Muthukuru [24] The unruly nodes that contravene the norm significantly undermine the performance of the virtuous nodes. Consequently, an intrusion detection system should be incorporated into the mobile ad-hoc network (MANET). This study examines wormhole and other deleterious malignant assaults in MANET. A wireless ad-hoc network, also known as a mobile ad-hoc network (MANET), is a collection of nodes that employs a wireless channel to transmit data and collaborate to facilitate information exchange between any two nodes, without a centralised framework. The security concern is a significant challenge in the utilisation of MANETs.

Sunitha, D., and P. H. Latha. [25] concentrated on identifying Black Hole assaults with sophisticated optimisation algorithms, specifically Grey Wolf Optimisation (GWO), Ant Colony Optimisation (ACO), Genetic Algorithm (GA), and Particle Swarm Optimisation (PSO). This survey seeks to improve the performance of MANETs by accurately recognising and minimising the effects of malicious nodes. The proposed method utilises the GWO algorithm to enhance routing pathways, hence increasing throughput and packet delivery ratio while minimising end-to-end delay. The ACO employed a systematic approach for routing decisions, incorporating pheromone updates and heuristic values to improve the efficacy of Black Hole attack detection. The GA framework incorporates Crossover and Mutation operators, facilitating a more systematic generation of nodes and enhancing flexibility to fluctuating network conditions. The PSO method employs a multidimensional strategy, including diversity optimisation and energy-efficient routing for Black Hole discovery. Therefore, the proposed method improves packet transmission in MANET and effectively secures the routing layer. Kaur, Arshdeep, and Jaspreet Kaur [26] presented a security mechanism based on trust. The trust parameters, determined by two factors: (i) Current Energy and (ii) Packed Drop



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Count of a node, are utilised to select IDS. The designated IDS node aids the source node in determining a data transmission pathway and thereafter oversees that route until the transmission concludes. The effects of each scenario are evaluated using PDR, NRL, and PLR, and the efficacy of the suggested approach is assessed through three different scenarios featuring varying quantities of attackers, mobility, and nodes.

Cherkaoui, Badreddine, *et al* [27] Proposed a black hole attack detection system utilising the Kolmogorov-Smirnov statistical approach. This technology is engineered to detect communication interruptions induced by such assaults without necessitating structural alterations to the routing protocol. The findings indicate that the suggested strategy can identify the occurrence of the assault through the observation of network activity. Malik, Abdul, *et al* [28] A novel method termed Detection and Prevention of a BHA (DPBHA) is presented to enhance the security and performance of VANETs by identifying BHA at an early stage of the route discovery process. The suggested approach involves computing a dynamic threshold value and creating a counterfeit route request (RREQ) packet. The solution is executed and assessed in the NS-2 simulator, and its performance and effectiveness are juxtaposed with the benchmark schemes.

Olanrewaju, Oyenike Mary, Abdulwasii Adebayo Abdulhafeez Abdulwasii, and Abdulhafiz Nuhu [29] Proposed an Enhanced On-demand Distance Vector (AODV) routing protocol to mitigate Blackhole attacks on MANETs utilising Diffie-Hellman and Message Digest 5 (DHMD), executed via Network Simulator 2 (NS2). The efficacy of the proposed protocol was assessed based on the following metrics: Packet Delivery Ratio, throughput, End-to-End (E2E) Delay, and routing overhead. It was determined that DHMD decreased network overhead to 23%, but AODV recorded 38%. Additionally, memory consumption for DHMD was 0.52 ms, in contrast to AODV's 0.81 ms, attributable to Blackhole prevention. This research aims to alleviate the impact of blackhole attacks on a network and enhance network performance by minimising overhead and memory usage. Kancharakuntla, Deepika, and Hosam El-Ocla [30] suggested an Enhanced Blackhole Resistance (EBR) protocol to detect and mitigate nodes accountable for blackhole attacks. EBR can circumvent congested traffic by routing data packets along a secure path with the minimal round-trip time (RTT). The EBR protocol employs a mix of time to live (TTL) and round trip time (RTT), referred to as a TR mechanism, to identify blackhole assaults. Our approach does not necessitate any cryptography or authentication procedures. Simulation studies demonstrate that EBR outperforms competing protocols for throughput, end-to-end delay, packet delivery ratio, energy efficiency, and routing overhead.

Research Gap

Detecting blackhole attacks is a significant challenge due to several factors:

- **Lack of Centralized Authority:** MANETs lack a central authority to monitor and validate the authenticity of routing information.
- **Dynamic Topology:** Frequent topology changes make it difficult to identify abnormal routing behavior or malicious nodes.
- **Resource Constraints:** Nodes in MANETs are often resource-constrained, with limited battery power, processing capability, and memory. Therefore, resource-intensive detection techniques may not be feasible.
- **False Positives:** Some detection methods may wrongly classify legitimate nodes as malicious, leading to unnecessary route changes and further degrading network performance.

Future Research Direction

The detection and mitigation of blackhole attacks in Mobile Ad Hoc Networks (MANETs) remain challenging due to the dynamic and decentralized nature of the network. While several detection methods have been proposed, each with its advantages and limitations, there are still significant gaps in developing robust and efficient solutions. Future research should focus on overcoming these challenges, exploring new techniques, and improving existing methods. Below are key future research directions for the detection of blackhole attacks in MANETs:

Trust-based and AI Integration: Combining trust-based models that monitor node behavior with AI techniques to enhance detection accuracy while adapting to dynamic network changes.



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Cross-layer Approaches: Investigating methods that gather information from multiple layers of the network (physical, data link, and network layers) to better understand node behavior and identify potential blackhole attackers.

Lightweight Hybrid Models: Developing resource-efficient hybrid detection mechanisms that do not impose excessive computational or energy burdens on resource-constrained nodes.

Energy-aware Detection Models: Designing lightweight algorithms that optimize energy consumption while maintaining high detection accuracy. Techniques like data aggregation and selective monitoring of nodes can help reduce unnecessary overhead.

Cooperative Trust Models: Developing trust models that allow nodes to collaboratively assess the behavior of their neighbors. A consensus-based approach can ensure that malicious nodes are detected more reliably, reducing false positives.

Advanced Collaborative Detection Algorithms: Developing advanced techniques to detect coordinated attacks involving multiple blackhole nodes. These methods could analyze node interactions and packet flow to identify suspicious patterns indicative of a collaborative attack.

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Application of Deep Learning Technique in the Detection of Knee Arthritis – A Literature Survey

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ABSTRACT

Knee arthritis is a prevalent degenerative joint disease, affecting millions globally and posing significant healthcare challenges. The early detection and accurate diagnosis of knee arthritis are crucial for effective treatment and management. Recent advancements in Deep Learning (DL), Machine Learning (ML), and Image Processing (IP) techniques have opened new avenues for improving diagnostic accuracy and automating the detection process. This literature survey explores the state-of-the-art methodologies employed in knee arthritis detection using these technologies. Key approaches discussed include convolutional neural networks (CNNs) for image classification, support vector machines (SVMs) and decision trees in ML-based classification, and image processing methods like edge detection and segmentation for enhancing radiographic images. The survey also reviews feature extraction techniques, such as texture analysis and wavelet transforms, along with optimization strategies for enhancing prediction performance. Furthermore, challenges such as imbalanced datasets, feature selection, and model interpretability are highlighted. This survey aims to provide a comprehensive understanding of the current landscape, addressing the gaps and future directions for improving knee arthritis detection through advanced computational techniques.

Keywords: Knee arthritis detection, Deep Learning, Machine Learning, Preprocessing, Classification, Image Processing





INTRODUCTION

Knee arthritis, a leading cause of disability worldwide, is characterized by the progressive degeneration of joint cartilage, leading to pain, stiffness, and reduced mobility. Osteoarthritis (OA) and rheumatoid arthritis (RA) are the most common forms of knee arthritis, and early detection is critical for slowing disease progression and improving patient outcomes. Traditionally, clinical diagnosis relies on patient history, physical examinations, and radiographic imaging, such as X-rays and MRI scans. However, these methods can be subjective and time-consuming, often resulting in delayed or inaccurate diagnosis [1]. In recent years, the integration of advanced computational techniques, including Deep Learning (DL), Machine Learning (ML), and Image Processing (IP), has shown significant promise in improving the detection and classification of knee arthritis. These methods offer automated, objective, and scalable solutions for analyzing medical images and identifying patterns that may not be apparent to the human eye. By leveraging large datasets and sophisticated algorithms, DL and ML techniques, such as Convolutional Neural Networks (CNNs), Support Vector Machines (SVMs), and Random Forests, can accurately classify the presence and severity of arthritis. Image processing methods, including image segmentation, feature extraction, and enhancement techniques, further aid in isolating key features within radiographic images for more precise diagnosis [2]. This literature survey aims to provide a comprehensive overview of the various DL, ML, and IP techniques employed for the detection of knee arthritis. It covers recent advancements, commonly used models, and innovative image processing approaches, highlighting their potential and limitations. The review also addresses key challenges such as data imbalance, model interpretability, and the need for better feature selection and optimization strategies. By examining existing methodologies, this survey seeks to identify gaps in current research and suggest directions for future work, with the ultimate goal of advancing the field of arthritis diagnosis through technological innovation.

Image Processing Techniques for the Detection of Knee Arthritis

Image processing [3] [4] plays a pivotal role in the detection and diagnosis of knee arthritis, enabling the enhancement, segmentation, and analysis of medical images to reveal critical features for accurate classification. Given the nature of medical imaging modalities, such as X-rays and MRI scans, image processing techniques help in isolating key regions of interest, improving contrast, and reducing noise, which can significantly aid in the automated detection of knee arthritis.

Image Preprocessing

Preprocessing is a fundamental step that prepares raw medical images for further analysis. Common preprocessing techniques [3] include:

Noise Reduction: Medical images often contain noise that can hinder the clarity of joint structures. Methods such as Gaussian filtering, median filtering, and wavelet-based denoising are employed to remove noise while preserving important features like bone contours and cartilage boundaries.

Histogram Equalization: This technique improves the contrast of images by redistributing pixel intensities, making it easier to differentiate between various tissues and the knee joint's structures.

Normalization: In knee arthritis detection, normalization ensures that images taken under different lighting conditions or settings have similar intensity levels, reducing variability.

Image Segmentation

Segmentation [4] is essential for isolating specific regions of interest, such as the knee joint, cartilage, or osteophytes (bone spurs), which are key indicators of arthritis. Common segmentation techniques include:

Thresholding: This basic technique segments the image based on pixel intensity. Adaptive thresholding can be used to handle images with varying illumination.





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Edge Detection: Methods like the Canny or Sobel edge detectors highlight boundaries between tissues, aiding in the identification of joint spaces, bone edges, and cartilage.

Active Contour Models (Snakes): This technique uses contours that evolve to fit the shape of the knee joint or other structures. It is particularly useful for segmenting complex shapes in noisy medical images.

Region Growing: This technique groups pixels with similar intensity values, enabling the segmentation of cartilage or other soft tissues that exhibit homogeneity.

Watershed Algorithm: Frequently applied in medical imaging, this method treats the image as a topographic surface and segments regions based on ridges or valleys, which can be useful in delineating bones from cartilage.

Feature Extraction

Feature extraction focuses on isolating and identifying specific attributes within the images that are indicative of arthritis [5]. Key techniques include:

Texture Analysis: Texture features, such as the coarseness or smoothness of cartilage, can be analyzed using techniques like Gray Level Co-occurrence Matrix (GLCM) and Local Binary Patterns (LBP). These methods extract texture information that can differentiate between healthy and arthritic tissue.

Shape Descriptors: These descriptors, including contour analysis and shape-based features, are used to evaluate joint space narrowing or bone deformities, which are common signs of arthritis.

Wavelet Transform: This technique is used for multi-resolution analysis of knee images. It helps in detecting fine structures within the joint space and can highlight regions affected by arthritis.

Image Enhancement

Image enhancement techniques are employed to improve the visibility of key features, such as cartilage degradation or bone spurs, which are essential for diagnosing arthritis:

Contrast Enhancement: Techniques like adaptive histogram equalization (AHE) or contrast-limited adaptive histogram equalization (CLAHE) are used to enhance contrast in areas where arthritis-related changes may be subtle.

Sharpening: Techniques like unsharp masking can enhance edges within the knee joint, making it easier to identify joint space narrowing or other deformities.

Super-Resolution Imaging: This advanced technique generates high-resolution images from lower-resolution data, improving the clarity of minute details in knee joints, aiding in the diagnosis of early-stage arthritis.

Deep Learning Techniques for the Detection of Knee Arthritis

Deep Learning (DL) [6] has revolutionized the field of medical image analysis, offering highly accurate and automated solutions for the detection of knee arthritis. By leveraging vast amounts of data and powerful computational architectures, DL techniques, particularly Convolutional Neural Networks (CNNs), have demonstrated exceptional performance in identifying arthritis-related features from medical images. This section outlines the key deep learning methodologies employed in the detection of knee arthritis, focusing on various neural network architectures, training strategies, and performance enhancements.

Convolutional Neural Networks (CNNs)

CNNs are the backbone of deep learning-based image analysis. They excel in learning spatial hierarchies from medical images, making them ideal for detecting knee arthritis through radiographic images such as X-rays and MRIs. Key CNN [7] [8] techniques used for knee arthritis detection include:



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AlexNet, VGG, and ResNet Architectures: These popular CNN architectures are widely applied for arthritis detection due to their capability to automatically extract relevant features from images. ResNet, with its residual connections, is particularly useful for addressing vanishing gradient issues in deep networks.

Pretrained Models and Transfer Learning: Given the scarcity of large labeled medical datasets, transfer learning plays a crucial role in knee arthritis detection. Pretrained models such as VGG16, ResNet, and Inception, trained on large datasets like ImageNet, can be fine-tuned for arthritis detection tasks. This approach reduces the need for extensive training data and allows the model to adapt quickly to the medical domain.

DenseNet and EfficientNet: These newer architectures emphasize parameter efficiency and feature reuse. DenseNet, with its densely connected layers, improves feature propagation and reduces the number of parameters, while EfficientNet scales network dimensions effectively, offering a good balance between accuracy and computational cost.

Fully Convolutional Networks (FCNs)

For precise segmentation of knee joint structures such as cartilage and bone, FCNs are employed. Unlike standard CNNs, FCNs replace fully connected layers with convolutional layers, allowing them to generate pixel-wise predictions for segmentation tasks. This is particularly useful in identifying joint space narrowing or cartilage loss, which are indicative of arthritis.

U-Net: U-Net is a popular fully convolutional network designed for medical image segmentation. It consists of a symmetric encoder-decoder architecture, where the encoder extracts hierarchical features from the input image, and the decoder uses these features to perform pixel-wise segmentation. U-Net is particularly effective for detecting joint boundaries and cartilage in knee arthritis.

SegNet: Similar to U-Net, SegNet uses an encoder-decoder structure but focuses on maintaining spatial information through max-pooling indices, making it efficient for segmentation of complex anatomical structures in knee joints.

Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM)

While CNNs are primarily used for spatial data, Recurrent Neural Networks (RNNs), particularly Long Short-Term Memory (LSTM) networks, can be integrated to handle temporal sequences [9][10]. In knee arthritis detection, LSTMs can be used in combination with CNNs to analyze a series of time-lapsed images (e.g., in longitudinal studies of arthritis progression) or to enhance decision-making by capturing dependencies between image slices in 3D MRI scans.

Attention Mechanisms

Attention mechanisms, which allow models to focus on specific regions of an image, have been increasingly applied to knee arthritis detection. By integrating attention layers within CNN architectures, these networks can prioritize areas in the image that are more likely to contain arthritis-related features, such as cartilage edges or joint spaces, thereby improving diagnostic accuracy.

Self-Attention and Transformers: Inspired by natural language processing, self-attention mechanisms and transformer-based architectures are now being explored for image analysis tasks. These models allow for global context awareness, which can be crucial for analyzing complex medical images where local and global features are equally important.

Generative Adversarial Networks (GANs)

Generative Adversarial Networks (GANs) have shown potential in the medical imaging field, including in knee arthritis detection. GANs consist of two networks—a generator and a discriminator—that work in opposition to improve the quality of generated images or features. In knee arthritis, GANs can be used for:



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Data Augmentation: GANs can generate synthetic images of knees with varying degrees of arthritis to augment limited datasets, improving the robustness of DL models in detecting early-stage arthritis or rare cases.

Image-to-Image Translation: GANs can translate X-ray images to high-resolution or enhanced versions, helping to detect minute changes in joint space or cartilage that might be missed in standard images.

Related Works

Sikkandar, Mohamed Yacin, *et al.* [11] A novel automatic classification of KOA images utilising an unsupervised local centre of mass (LCM) segmentation technique and a deep Siamese Convolutional Neural Network (CNN) is introduced. First-order statistics and the GLCM matrix are employed to extract KOA anatomical features from segmented images. Bayramoglu, Neslihan, Miika T. Nieminen, and Simo Saarakkala [12] Utilised lateral view knee radiographs from The Multicenter Osteoarthritis Study (MOST) public use datasets (n = 5507 knees). The patellar region of interest (ROI) was automatically identified using the landmark recognition program (BoneFinder), and these anatomical landmarks were later employed to generate three distinct textural ROIs. Features meticulously created from Local Binary Patterns (LBP) were subsequently extracted to characterise the patellar texture. A Gradient Boosting Machine model was initially developed to identify radiographic Perfluorooctanoate (PFOA) using LBP characteristics. Additionally, we employed end-to-end trained deep convolutional neural networks (CNNs) directly on the texture patches for the detection of PFOA.

Supriya, M., and Thayyaba Khatoon Mohammed [13] suggested a hybrid model that integrates sophisticated computer vision methodologies, including Scale-Invariant Feature Transform (SIFT) and Speeded Up Robust Features (SURF), with Support Vector Machines (SVM) and Random Forests. The amalgamation of SIFT and SURF facilitates the extraction of resilient and distinguishing features from knee joint images, essential for precise classification. The SVM and Random Forest algorithms are utilised to categorise these traits, offering an effective means to differentiate between healthy and sick states. We employ a comprehensive array of knee images, encompassing MRIs, CT scans, and X-rays, to train and refine the model, guaranteeing its capability to manage diverse imaging modalities and situations. Abdullah, S. Sheik, and M. Pallikonda Rajasekaran [14] Created a tool for identifying and assessing knee osteoarthritis (OA) using digital X-ray images, demonstrating the potential of deep learning methods to predict knee OA according to the Kellgren-Lawrence (KL) grading system. The objective of the study is to evaluate the efficacy of an artificial intelligence (AI)-driven deep learning method in identifying and assessing the severity of knee osteoarthritis (OA) in digital X-ray images.

Khamparia, Aditya, *et al* [15] Proposed a novel feature extractor from X-ray images of the knee to aid in detection and classification, termed explainable Renyi entropic segmentation inside an Internet of Things (IoT) framework. The suggested method thereafter employs a model-agnostic algorithm utilising post hoc explainability to retrieve pertinent information from knee joint segmentation predictions. The CAD system is connected with an IoT framework and can be utilised remotely to aid medical practitioners in the treatment of knee arthritis. Karpiński, Robert [16] Presented the findings of a preliminary investigation on the simplified diagnosis of knee joint osteoarthritis based on generated vibroacoustic processes. The investigation utilised acoustic signals obtained from a cohort of 50 individuals, comprising 25 healthy subjects and 25 individuals with previously established degenerative abnormalities. The chosen discriminants of the signals were identified, and statistical analysis was conducted to facilitate the selection of ideal discriminants for subsequent usage as input to the classifier. The optimal outcomes of classification utilising artificial neural networks (ANN) of Radial Basis Function (RBF) and Multilayer Perceptron (MLP) kinds are shown.

Trejo-Chavez, Omar, *et al* [17] The primary contribution described is a methodology utilising infrared thermography (IT) and convolutional neural networks (CNNs) to autonomously distinguish between a healthy knee and an injured knee, serving as an alternative tool to assist medical professionals. The methodology comprises three steps: (1) database building, (2) image processing, and (3) construction and validation of a CNN for the automatic identification of patients with knee injuries. During the image-processing phase, greyscale images, equalised images,



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and thermal images serve as inputs for the CNN, achieving an accuracy of 98.72% with the suggested technique. Bose, Anandh Sam Chandra, C. Srinivasan, and S. Immaculate Joy [18] This research examines the crucial function of FS in improving the precision and reliability of ML models employed in KOA detection and severity categorisation. The data were sourced from Kaggle, reflecting diverse grades of KOA. We utilise a Convolutional Neural Network (CNN) model to extract characteristics from medical imaging data. Employing sophisticated methodologies like Particle Swarm Optimisation (PSO) and Genetic Bee Colony (GBC), we methodically discern important features to improve our machine learning models.

Sharma, Neha, Riya Sapra, and Parneeta Dhaliwal [19] Examined numerous medical imaging modalities applicable for the detection or diagnosis of Knee Osteoarthritis (KOA) and explored diverse Machine Learning algorithms that facilitate the automated identification of KOA with minimal human involvement. "Joint inflammation" is the synonym for arthritis. Joints are defined as the anatomical regions where two bones converge, facilitating movement, exemplified by the elbow and knee. Arthritis is a prevalent condition that is among the leading causes of global disability. Osteoarthritis is a form of arthritis that mostly arises from recurrent stress on joint cartilage. Osteoarthritis is also referred to as "degenerative" arthritis. Utilising machine learning concepts on medical data can substantially enhance disease detection and early diagnosis. This research provides a comprehensive overview of several medical imaging approaches that enable automated diagnosis of KOA using advanced machine learning methods. Song, Jiangling, and Rui Zhang [20] Concentrate on researching the computer-assisted diagnosis technique for knee osteoarthritis (KOA-CAD) utilising multivariate data, specifically vascular activity graphs (VAGs) and fundamental physiological signals, through an enhanced deep learning model (DLM). A novel Laplace distribution-based technique (LD-S) for classification in DLM is developed. Secondly, an aggregated multiscale dilated convolution network (AMD-CNN) is developed to extract features from the multivariate data of KOA patients. A novel KOA-CAD method is introduced, combining the AMD-CNN with the LD-S to achieve three CAD objectives: automatic KOA identification, early KOA detection, and KOA grading detection.

Zhao, Zhengkuan, *et al* [21] The primary purpose was to employ machine learning techniques to discern critical structural features correlated with pain severity in patients with knee osteoarthritis. Furthermore, we evaluated the efficacy of several categories of imaging data through machine learning methodologies to determine the degree of knee discomfort. Data from semi-quantitative evaluations of knee radiographs, semi-quantitative assessments of knee magnetic resonance imaging (MRI), and MRI images of 567 participants in the Osteoarthritis Initiative (OAI) were employed to build a set of machine learning models. Models were developed employing five machine learning techniques: random forests (RF), support vector machines (SVM), logistic regression (LR), decision trees (DT), and Bayesian approaches (Bayes). Utilising tenfold cross-validation, we identified the optimal models based on the area under the curve (AUC). Patil, Pradnya, *et al.* [22] Formulated a prediction model for Knee Osteoarthritis (KOA) utilising X-ray images and the Kellgren-Lawrence (KL) scale to ascertain the existence of KOA. Medical images, namely knee X-rays, were gathered and categorised by radiologists according to the KL scale, which ranges from 0 (absence of KOA) to 4 (severe KOA). Convolutional neural network (CNN) modelling is employed to analyse X-ray images and predict the KL score.

Zebari, Dilovan Asaad, Shereen Saleem Sadiq, and Dawlat Mustafa Sulaiman [23] Introduced a technique utilising deep features. We utilised a Convolutional Neural Network to extract deep information from images of Knee Osteoarthritis. The collected characteristics are subsequently input into various machine learning classifiers, specifically Support Vector Machine, K-Nearest Neighbour, and Naive Bayes. This study has been classified to distinguish between healthy and unhealthy Knee Osteoarthritis images. Kijowski, Richard, Jan Fritz, and Cem M. Deniz [24] Various deep learning methodologies have been delineated for the fully automated segmentation of cartilage and other knee tissues, attaining superior segmentation accuracy compared to existing techniques while significantly decreasing segmentation durations. Multiple deep learning models have been created for the assessment of osteoarthritis risk by analysing baseline X-rays and MRIs. These models have demonstrated superior diagnostic efficacy in forecasting several outcomes of osteoarthritis (OA), including the incidence and advancement of radiographic knee OA, the emergence and progression of knee pain, and the likelihood of future total knee



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arthroplasty. The initial outcomes of deep learning applications in optical coherence imaging have proven promising. Nonetheless, numerous deep learning techniques necessitate additional technical enhancement to optimise diagnostic efficacy. Sharmila Begum, M., *et al* [25]. Proposed an artificial intelligence process for selecting an abstract set of characteristics from the provided raw data, with classification performed via Hybrid Isolation Forest (HIF). The chapter has three steps, beginning with the processing of raw images and the extraction of the pre-processed dataset. The second phase delineates the abstract feature set through statistical and regressive parameters. The third phase introduces a hybrid isolation forest methodology that amalgamates probability distribution with isolation forest techniques to achieve precise classification of normal and anomalous data samples. The suggested AI model is evaluated using the knee joint dysfunction image dataset.

Research Gap

Despite significant advancements in image processing and deep learning (DL) techniques for the detection of knee arthritis, several challenges and research gaps remain. These limitations present opportunities for further research to improve diagnostic accuracy, model robustness, and clinical applicability. The following outlines key research gaps in this domain:

Data Scarcity: One of the major challenges is the lack of large, annotated datasets specific to knee arthritis. Existing datasets, such as the Osteoarthritis Initiative (OAI), are valuable but often limited in terms of diversity, image types (e.g., X-rays versus MRI), and varying levels of disease severity.

Diversity in Imaging Modalities: Most studies focus on a single imaging modality, such as X-rays, while limited work has been done on multi-modal approaches (e.g., combining MRI, X-rays, and CT scans). Integrating data from different modalities could improve diagnosis, but it also introduces challenges in data alignment and fusion.

Class Imbalance: Datasets are often heavily skewed, with a higher prevalence of moderate or severe arthritis cases, leading to biased models that may underperform in detecting early-stage arthritis.

Overfitting: Deep learning models trained on limited datasets are prone to overfitting, where they perform well on the training data but fail to generalize to new, unseen images. This is a particularly challenging issue in medical imaging, where obtaining large, high-quality labeled datasets is difficult.

Lack of Optimal Feature Selection Techniques: Identifying the most relevant features for arthritis detection is crucial, yet many models rely on deep learning's automatic feature extraction without fully exploring optimal feature selection methods. Techniques such as wavelet transforms, texture analysis, or hybrid feature extraction approaches (e.g., combining spatial and frequency domain features) could be further explored to enhance detection performance.

Future Research Direction

Given the current research gaps in knee arthritis detection using image processing and deep learning techniques, several promising avenues for future exploration can be pursued. These research directions aim to enhance model performance, clinical applicability, and the development of real-time, deployable solutions for early and accurate detection of knee arthritis.

Hybrid Models for Enhanced Feature Extraction: Combining CNNs with traditional image processing techniques (e.g., wavelets, texture analysis) or using advanced feature selection methods could improve model performance. Such hybrid models would benefit from the interpretability of classical methods while leveraging the powerful feature extraction capabilities of deep learning.

CNN + RNN/LSTM Architectures: Developing hybrid models that combine spatial feature extraction (via CNNs) with temporal analysis (via LSTMs or RNNs) can allow for more accurate predictions based on image sequences or longitudinal data.



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Unsupervised Learning for Feature Discovery: In addition to supervised learning, unsupervised or semi-supervised learning methods should be investigated to discover new, clinically relevant features in knee images. This could lead to the identification of novel biomarkers for early arthritis detection.

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A Generic Approach for Software Metrics Based Software Defect Prediction

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ABSTRACT

Software performance error detection is an essential non-functional requirement, which appears in many fields such as complex applications and real-time application development. In this work, he focuses on early detection of performance bugs. The proposed work finds a robust and reliable solution to enforce and predict performance errors. Compared with the proposed new algorithm for defect prediction, we construct several methods using ML algorithms: C4.5 decision tree, naive Bayes, Bayesian network and logistic regression. That's what our exact outcomes show the model proposed using the modified line of code MCCABE/HALSTEAD can be used to predict performance errors with an accuracy of 0.94 and 0.96. We show that reducing the number of committed changes in a commit reduces the chance of injecting performance bugs. This approach helps professionals eliminate performance bugs early in the development cycle. Our results are also of interest to theorists, as they establish a link between functional errors and performance errors, and clearly show that attributes are used to predict functional metrics.

Keywords: Defect prediction, features based, machine learning, performance analysis, regression model, SDLC.





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INTRODUCTION

Data mining is the business of analyzing information from different angles and fusion or compressing it into important and meaningful data. Data mining techniques such as feature extraction and classification techniques have proven to be very effective in predicting defects in biological substances, irregularities in clinical data, and revealing important medical facts that inspire the exploration of such treatments, pharmacology, and clinical decision-making pathway of interest. Feature extraction is the technique of deciding on effective methods or subsets of features to create powerful unsupervised learning models. Classification is a data analysis technique used to distinguish important categories/categories of data. This work aims to identify the optimal and minimal set of software defect models for more accurate identification of software failure propensities in programmed systems. The final performance metrics used to evaluate the current method include precision, sensitivity, and specificity.

Software bugs are often not discovered until late in the development cycle, at which point it is expensive to go back and fix them. Addressing these bugs is a critical flaw that can build an application developer's reputation for delivering products or creating life-threatening situations when the software is part of a larger system or device, such as defense equipment or medical equipment. Therefore, methods for predicting software failures Further improving the quality of programming used in Defense Force programs is the rationale for this research effort. In the literature, several articles have been presented on software faults using mining strategies by predictive methods. Some papers discuss failure prediction methods such as measures of size and complexity, multivariate analysis, and multicollinearity using Bayesian conviction systems. NB is widely used to build classifiers. When building a defect predictor, the probability of each class is computed, given the extracted properties of a module, to predict a defective module using an applicable measure, such as Halstead and McCabe *et al.* This work develops prediction rules for fault attributes using a Naive Bayesian classifier (NB). The focus of this work is to construct effective methods for software fault prediction. We summarize this work for three fundamental reasons: the work creates datasets from publicly available procedural resources; the reported accuracy of combined techniques shows much room for development; the design of more accurate failure prediction techniques can Significantly currently used in the defense framework.

Related Work

Several previous studies analyzed the impact of current contribution behavior on software quality. Examined the effects of ownership and experience on the nature of various open-source projects using a detailed approach based on fix-inducing code fragments and reported similar findings to our paper (Malhotra, Ruchika, and Juhi Jain.2020). However, they operate differently on ownership, and ownership policies and practices in OSS and commercial software are very different. So, the similarity in effect is surprising. Furthermore, Rahman and Devanbu. 2010 did not study the secondary contribution relationship of software dependencies; nor did they consider social media metrics. Concentrated on the impact of counting group size in predictive models (Banga, Manu, and Abhay Bansal. 2020). They use the number of developers for each component, but don't check the percentage of work we explain. They found that failure prediction accuracy could be improved by trivially adding device dimensions to the model. We are different in that we examine the proportion of each developer's contribution to the component. Also, we are not interested in predictions, but there is a statistically significant relationship between attribute determination and failure.

Similarly, Reddy, K. Narsimha, and Polaiah Bojja. 2022studied the relationship between some developers and security vulnerabilities. They found that a security breach was 16 times more likely to occur if more than nine developers contributed to a source file. New approaches such as Extreme Programming (XP) (Chakraborty *et al.* 2020) claim ownership of collective code, but there is little empirical evidence or support for such information in considerably larger or more difficult applications. Our study is the first to empirically quantify the impact of code owners (and inexperienced contributors) on overall code quality. Execution bugs are more diligently to uncover during the testing stage since they don't cause lethal side effects and don't affect the overall results. Pant *et al.*2022.



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Furthermore, it is difficult to find the root cause of performance bugs (compared to other types of bugs); they also take longer to resolve (Goyal and Somya 2020).

The closest work to ours is that of Ekenet *et al.* 2021, who studied a set of 109 real-world performance bugs. They study the lifecycle of errors from creation to correction, root causes, and introduction mechanisms to create rule-based detectors. We use a similar approach to create detectors (called "patterns" in our research) to identify similar performance errors. They examined software written in Java, C, C++, and JavaScript; our program was written in MATLAB. Additionally, we focused on finding an efficient way to automatically detect performance bugs (197 real-world performance bugs in our example) based on data extracted from usage patterns. In summary, focused on analyzing performance bug characteristics, whereas in this study we aim to understand the contribution of each source code attribute retrieved from a source code repository to the predictive power of various algorithms (Malhotra, Ruchika. 2020). We use automatic algorithms. Finally, our general approach and methodology for building predictive models is designed to be easily reproducible in the future. Therefore, our work is complementary.

Automatic performance bug detection has been implemented in the past (Banga, *et al.* 2020), (Hosseinipour, *et al.* 2022). However, the authors use dynamic analysis tools, namely execution traces and historical performance data, to detect slow-running code. Additionally, dynamic analysis tools often require a dedicated test environment to get accurate performance readings. On the other hand, we leverage code properties pulled from source code repositories and automatically catch performance bugs before the code is executed (and put into production). Accordingly, our work is reciprocal. Static examination devices can likewise dispose of execution bugs (Reddy, *et al.* 2022). In any case, this approach requires information on pattern formats, while our approach does not (since we omit schema type information from the model), so our work is relevant. RTS has formal and comprehensive coding standards. However, standards are usually language-specific (for example, C (Dereli, and Serkan, 2022.) and C++ (Sharma, *et al.* 2022). Apparently, there is no finished furthermore, formal RTS coding standard for MATLAB. At last, since in our review we relate execution to the continuous idea of the framework, it can be argued that programming languages may not be suitable for this situation. While this is an inquiry. We grasp its significance and legitimacy outside the extent of this review. This programming language (with a suitable runtime (Nitta, *et al.* 2022)) is used in known large-scale RTS.

The Table 1 presents a comparative analysis of previous research and the current study on software defect prediction, focusing specifically on performance bugs. Malhotra and Ruchika's work shares similarities with the current research in analyzing ownership and experience effects on software quality but lacks exploration of secondary contribution relationships in software dependencies. Banga and Manu's study highlights the impact of group size on predictive models, improving prediction accuracy, yet it overlooks the proportion of each developer's contribution. Menely and Williams emphasize the relationship between developers and security vulnerabilities, diverging from performance bug analysis. Jin *et al.* undertake a lifecycle study of real-world performance bugs, albeit in different programming languages than the current study. Previous works generally analyze performance bug characteristics, but lack focus on automatic algorithms and reproducibility. Past implementations prioritize dynamic analysis, while the current study emphasizes static examination, though omitting schema type information and relevance to MATLAB coding standards. Overall, the current study bridges gaps in previous research by focusing on automatic algorithms, reproducibility, and relevance to MATLAB coding standards for performance bug detection.

METHODOLOGY

Data Preparation

We removed all records that didn't go into the indicator extraction library, namely: readme, test scripts and help documents. Additionally, we eliminated 0.2% (9 out of 4623 extraordinary tuples) of "commit ID-filename" records connected with source code documents. These records are outliers, corner cases. For instance, we exclude source files that have been moved or deleted. More specifically, version control systems by default recognize index





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changes/refactoring's as complete cancellations of the actual records. So, whenever a file moves up or down at least one levels in the registry structure, we notice an unusual number of lines being added or removed. In some of these cases (particularly registries with huge records) in excess of 10,000 lines were added or taken out in a solitary commit. The above cleanups lead to more accurate model building, mainly due to the evacuation of sections that won't be found in future commits. The "Data Preparation Workflow" Figure 1 provides a visual overview of the steps involved in preparing the data for analysis. The process begins with data cleaning, where any inconsistencies or errors in the dataset are addressed. Next, the need for outlier removal is evaluated, and if necessary, outliers are removed to ensure the integrity of the data. Following this, the dataset selection step involves selecting the appropriate dataset for analysis. Once these steps are completed, the data is ready for further analysis and processing. This diagram serves as a guide for researchers and readers, outlining the essential steps in data preparation before conducting any analysis, thereby ensuring the quality and reliability of the data used in the study.

Metrics Extraction

Features are extracted based on McCabe and Halstead metrics. The Table 2 below defines the flaw detector evaluation.

			module	actually	has
			defects		
				No	Yes
classifier	predicts	no	No	tp	Fn
defects					
classifier	predicts	Some	Yes	fp	tn
defects					

$$\text{Accuracy} = \frac{\text{True Positives} + \text{True Negatives}}{\text{True Positives} + \text{False Positives} + \text{True Negatives} + \text{False Negatives}}$$

$$\text{Recall} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Negatives}}$$

$$\text{Precision} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}}$$

$$\text{Effort} = \frac{\text{False Positives} \times \text{LOC} + \text{True Negatives} \times \text{LOC}}{\text{Total LOC}}$$

The Four McCabe software metrics are: Essential complexity, cyclomatic complexity, design complexity and LOC. Table 2 offers a comprehensive overview of the metrics extracted from software code, encompassing both McCabe and Halstead metrics along with their respective definitions and calculation methods. Each metric, ranging from LOC (McCabe's line count of code) to Total Operators (Halstead), provides crucial insights into different aspects of the code's complexity, including program length, essential complexity, and design complexity. For instance, Cyclomatic Complexity (v(g)) measures program complexity by assessing the number of linearly independent paths through the code, while Volume (v) calculates the vocabulary size multiplied by the logarithm of program length, indicating the overall size of the codebase. This Table 2 serves as a valuable reference for researchers and practitioners alike, enabling a deeper understanding of software code characteristics and facilitating informed decision-making in software development and maintenance processes.

Attribute Information

The "Attribute Information Table 3" serves as a comprehensive reference for understanding the attributes utilized in the study for software defect prediction. Each attribute, ranging from McCabe's line count of code to various metrics derived from Halstead's analysis, is detailed along with its significance in software defect prediction. For instance,



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McCabe's line count of code provides insights into code size and complexity, while metrics like Cyclomatic Complexity and Design Complexity offer measures of program structural complexity and potential design flaws, respectively. Halstead's metrics, such as Volume and Effort, quantify aspects like code size and development effort, crucial for predicting software defects. Additionally, attributes like Comment Count and Blank Line Count shed light on code documentation and readability, factors influencing software quality. This Table 3 not only aids in understanding the attributes used in the study but also highlights their roles in predicting and mitigating software defects, facilitating informed decision-making in software development and maintenance processes.

Rule Mining

Based on recommended intervals, we characterize basic principles for every measurement. These standards fire if a module's metrics are not within the specified interval (which means checking the module manually). It shows 12 base rules with their corresponding flags, and 2 derived rules. The first derivative rule, rule 13, defines the partition of the 12 basic rules. If it triggers some ground rules, that's Rule 13 triggering. The explanation is that the corresponding annotations and intervals associated with the Halstead measure do not conform to the properties of Turkcell encoding. One solution is to define new ranges for these metrics. However, this is not possible since there is no defect data to derive these detection trigger intervals. To overcome this, we defined rule 14, if all basic rules are on, but Halsted fires. This reduces the frequency of rule extraction. However, Rule 14 states that module 9556 corresponding to 461.655 LOC must be checked for possible defects. Validating 45% of the total LOC is impractical. Then again, it would be more effective to demonstrate learning-based models.

Figure 2 depicts the systematic approach to deriving rules for software defect prediction. In the "Identification of Basic Principles" phase, metric intervals and thresholds are established to define the boundaries for determining if a module's metrics fall within acceptable ranges. These intervals serve as the foundation for generating rules. The process then transitions to the "Derivation of Rules" phase, where base rules are formulated based on the identified intervals. These base rules serve as the initial guidelines for identifying potential software defects. Additionally, derived rules are generated from the base rules, further refining the criteria for defect prediction. This iterative process ensures that comprehensive rules are established, incorporating various metrics and thresholds to effectively identify and mitigate software defects.

Performance Bug Prediction

Figure 3 illustrates the sequential steps involved in the process of predicting performance bugs within software systems. It begins with Data Preprocessing, where raw data is cleaned and prepared for analysis. Following this, Metric Extraction extracts relevant metrics from the data, providing valuable insights into the software's performance characteristics. Rule Mining establishes rules based on identified intervals and thresholds, aiding in the identification of potential performance issues. Subsequently, Weighting Factor Prediction assigns weights to different factors based on their importance in predicting performance bugs. Data Information Classification organizes the data into relevant categories for analysis. Finally, Model Validation validates the predictive models developed using cross-validation techniques, ensuring their accuracy and reliability in predicting performance bugs. This workflow provides a structured approach to effectively identify and mitigate performance issues within software systems. The method proposed in this work for predicting software defects consists of two phases: a data processing phase; and a verification phase. This work involves data preprocessing, metric extraction, rule mining, weighting factor prediction, and data information classification. The next stage consists of validating the presentation of the classifiers studied in this study and their rules using cross-validation techniques, and classifying the presentation of the classifiers in terms of classification accuracy and recall. The methodology followed in this research work is detailed in the accompanying portion. The automated prediction of software fault is depending on two criteria. One is sensitivity of the prediction and the other one is specificity. The both were measured in confusion matrix and calculated as





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$$\text{sensitivity} = \frac{\text{number of true positives}}{\text{number of true positives} + \text{number of false negatives}}$$

$$\text{specificity} = \frac{\text{number of true negatives}}{\text{number of true negatives} + \text{number of false positives}}$$

The above two tests are helpful to know the accurate prediction.

EXPERIMENTAL RESULTS

Removed Constant Attributes

A property that has a steady/fixed esteem across all examples is effectively recognizable on the grounds that it has zero fluctuation. These attributes do not have any information to distinguish the modules and at best are a waste of classifier resources. The dataset has 5 constant attributes out of 22 attributes, so 45% of the available log values do not contain information to extract data from.

Removed Redundant Attributes

Except for consistent properties, duplicate properties occur when two properties have the same value for each instance. This results in individual attributes being over-represented. In the dataset, there are only a few attributes that are repeated, specifically the "Quantity of Lines" and "All out Position" ascribes in the dataset. At this stage we remove one of the properties so that the value will only be rendered once. We chose to keep the "total position" attribute label, as this is a common usage of our dataset.

Replaced Missing Values

Depending on the classification method used, these values may or may not be problematic for machine learners. 19 records in the dataset contain missing values, but all belong to the same attribute: "decision density". This attribute is defined as "Condition Count" divided by "Decision Count", and for each missing value, the value of both base attributes is zero.

RESULTS

In this present work, the software metric 21 are form McCabe's and Halstead metrics and one goal metric were in the present work, software metrics 21 are McCabe and Halstead metrics and are measured using objective metrics. Using MATLAB tools, the dataset was applied to the Naive Bayesian classifier and the proposed algorithm. This dataset has been combined according to structure and object orientation. in C and C++ languages. The study compared mean precision (values in the table from 0 to 1), true positive rate, false positive rate, sensitivity and specificity. Accuracy (Figure 4) calculated from the quantity of accurately ordered cases. Based on the consequences of these investigations, the proposed technique is applicable to both large and small datasets. The Table 4 below gives the correctly and misclassified instances and the absolute number of occasions in the dataset using different classifiers. It also provides the best highlighted classifier based on sensitivity and specificity values Table 5

Figure 5 illustrates the trade-off between the true positive rate (sensitivity) and the false positive rate for two classifiers, both on the training and testing sets. Each curve represents the performance of a classifier, with the area under the curve (AUC) indicating its discriminative power. A steeper curve and a larger AUC value signify better classification performance. The plot also includes a diagonal dashed line representing the performance of a random classifier. The closer a curve is to the upper-left corner of the plot, the better the classifier's performance. Overall, the ROC Curve plot provides a visual comparison of classifier performance, aiding in the selection of the most effective model for the task at hand. Figure 6 illustrates the trade-off between precision and recall for two classifiers, both on the training and testing sets. Each curve represents the performance of a classifier, with the area under the curve



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(Average Precision) indicating its overall performance. A curve that is closer to the upper-right corner of the plot signifies a classifier with higher precision and recall rates. The plot provides insights into the balance between precision and recall for different classifiers, helping in the selection of the most suitable model for the task at hand. Additionally, the average precision values provide a quantitative measure of the classifiers' performance, with higher values indicating better overall performance.

CONCLUSION

In this proposed work, module performance errors in enormous programming frameworks are anticipated. This work analyzed an average case of 25 projects to characterize the carried-out code base and noticed measurements that contradicted the company's goals. Our initial data analysis shows that a simple rule-based model based on static code attribute recommendation criteria estimates the defect rate of code under verification. Given the extent of the framework, this is an unrealistic result. Therefore, we built a learning-based defect predictor and performed additional analyses. Due to the lack of defect data at the local module level, we use synthetic data to learn a defect predictor. Preliminary analysis confirmed the average defect rate for all projects. While simple rule-based modules require checking the code, learning-based models suggest that we only need to verify 6% of the code. This is because rule-based models are biased toward larger and more complex modules, while learning-based models predict smaller modules to contain the most defects. The results of our second analysis used data that fit the framework. External validation of the data did not change the median probability of detection and significantly reduced the median probability of false positives. A second analysis further improved the estimates and suggested that only 93% of the code and 93% of the defects could be detected. Our future work is to collect local software-level defects to build predictors for this large telecom system within the enterprise. In addition to using block-level code as an indicator to predict semantic and performance defects between successive software releases

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Table 1: Research Gap

Author Name	Proposed Methodology	Results	Research Gap
Malhotra, Ruchika	Detailed analysis of ownership & experience effects	Similar findings to current research	Lack of exploration of secondary contribution relationship of software dependencies
Banga, Manu	Impact of group size in predictive models	Improved prediction accuracy by group size	Did not consider proportion of each developer's contribution; focused on prediction accuracy
Menely and Williams	Relationship between developers & vulnerabilities	Increased likelihood of security breach with multiple developers	Focus on security vulnerabilities rather than performance bugs
Jin <i>et al.</i>	Lifecycle study of real-world performance bugs	Creation to correction lifecycle analysis	Focused on Java, C, C++, and JavaScript; different programming language (MATLAB)
Previous works	Analysis of performance bug	Understanding source code attribute contribution to	Lack of focus on automatic algorithms; lack of reproducibility





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	characteristics	predictive algorithms	in methodology
Past implementations	Dynamic analysis for performance bug detection	Utilized execution traces and historical data	Lack of focus on static examination; requirement of dedicated test environment for accuracy
Current study	Static examination for performance bug detection	Utilizes code properties from source repositories	Omission of schema type information; relevance to MATLAB coding standards

Table 2: Summary of Software Code Metrics

Metric	Definition	Calculation Method
LOC	McCabe's line count of code	Count of lines in the source code
Cyclomatic Complexity (v(g))	Measure of program complexity	Number of linearly independent paths through a program's source code
Essential Complexity (ev(g))	Measure of essential complexity	Number of linearly independent paths that must be tested
Design Complexity (iv(g))	Measure of design complexity	Number of linearly independent paths that are executable
Total Operators and Operands (n)	Halstead total operators + operands	Count of all unique operators and operands in the source code
Volume (v)	Halstead "volume"	Total vocabulary size multiplied by the logarithm of the program length
Program Length (l)	Halstead "program length"	Total number of unique operators and operands in the source code
Difficulty (D)	Halstead "difficulty"	Volume divided by the program length multiplied by the number of unique operators
Intelligence (i)	Halstead "intelligence"	Program length divided by the number of unique operators
Effort (e)	Halstead "effort"	Difficulty multiplied by volume
Bugs (b)	Halstead "bugs"	Volume divided by 3000
Time Estimator (T)	Halstead's time estimator	Effort divided by 18
Line Count (IOCode)	Halstead's line count	Total number of lines of code in the source code
Comment Count (IOComment)	Halstead's count of lines of comments	Total number of lines of comments in the source code
Blank Line Count (IOBlank)	Halstead's count of blank lines	Total number of blank lines in the source code
Code and Comment Line Count (IOCodeAndComment)	Numeric	Total number of lines of code and comments in the source code
Unique Operators (uniq_Op)	Unique operators	Count of unique operators in the source code
Unique Operands (uniq_Opnd)	Unique operands	Count of unique operands in the source code
Total Operators (total_Op)	Total operators	Count of all operators in the source code





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Table 3: Attribute Information

Attribute name	Description
Loc	McCabe's line count of code
v(g)	McCabe "cyclomatic complexity"
ev(g)	McCabe "essential complexity"
iv(g)	McCabe "design complexity"
n	Halstead total operators + operands
v	Halstead "volume"
l	Halstead "program length"
D	Halstead "difficulty"
i	Halstead "intelligence"
e	Halstead "effort"
b	Halstead
T	Halstead's time estimator
IOCode	Halstead's line count
IOComment	Halstead's count of lines of comments
IOBlank	Halstead's count of blank lines
IOCodeAnd Comment	Numeric
uniq_Op	unique operators
uniq_Opnd	unique operands
total_Op	total operators

Table 4: Classification Results of Proposed Work

Dataset	Accurately Classified Instances	In-accurately Classified Instances	Total Instances
Training Set	3792	222	4014
Testing Set	4519	481	5000

Table 5: Performance measure of proposed work

Dataset	Sensitivity	Specificity	Accuracy
Training Set	0.982	0.978	94.36
Testing Set	0.996	0.999	97.81

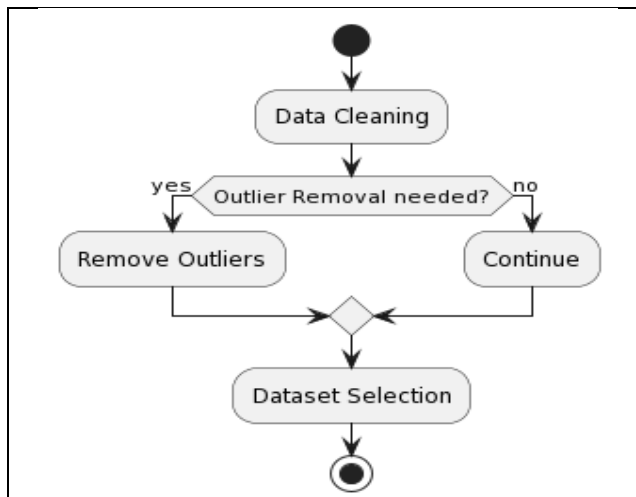


Figure 1: Data Preparation Workflow

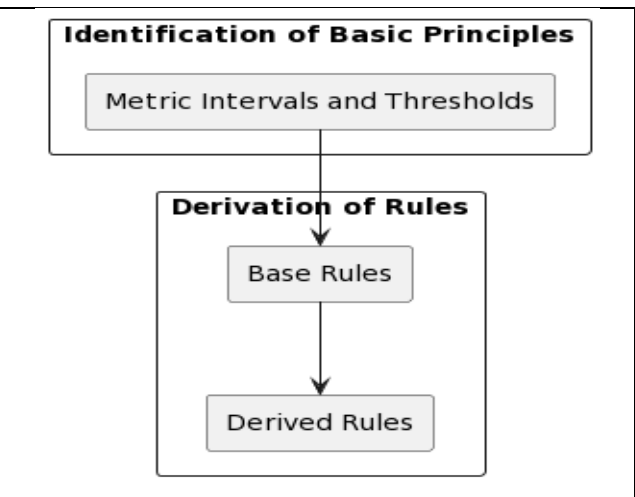


Figure 2: Rule Mining Process Diagram





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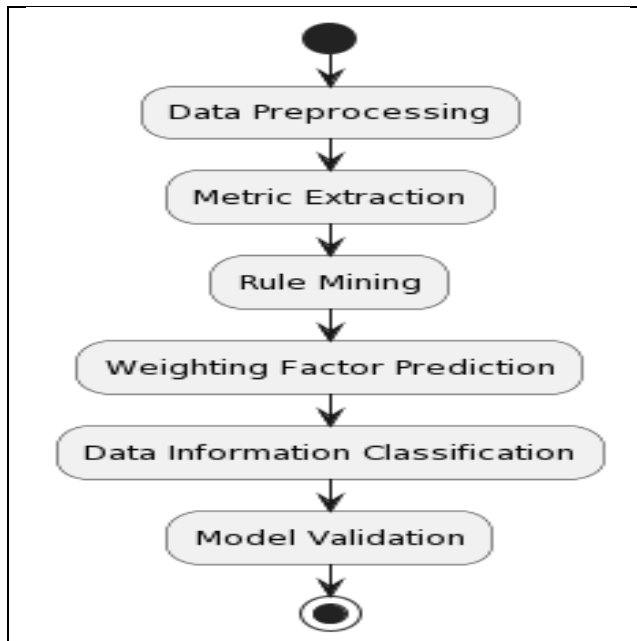


Figure 3: Performance Bug Prediction Workflow

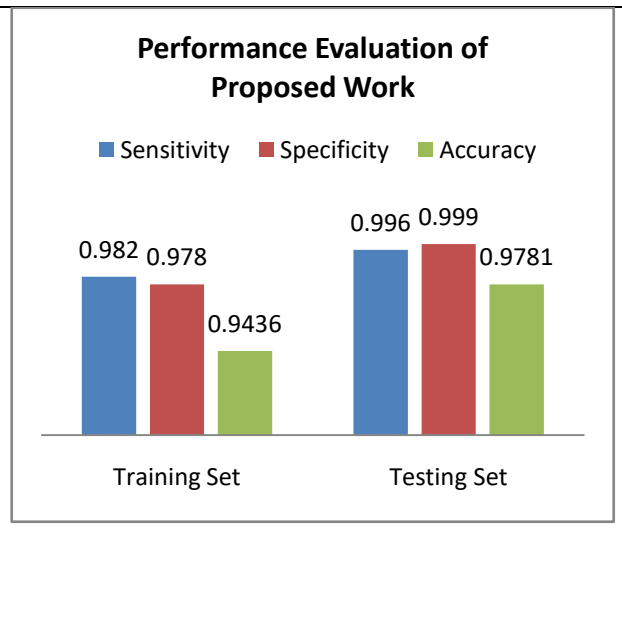


Figure 4: Performance Evaluation of proposed work

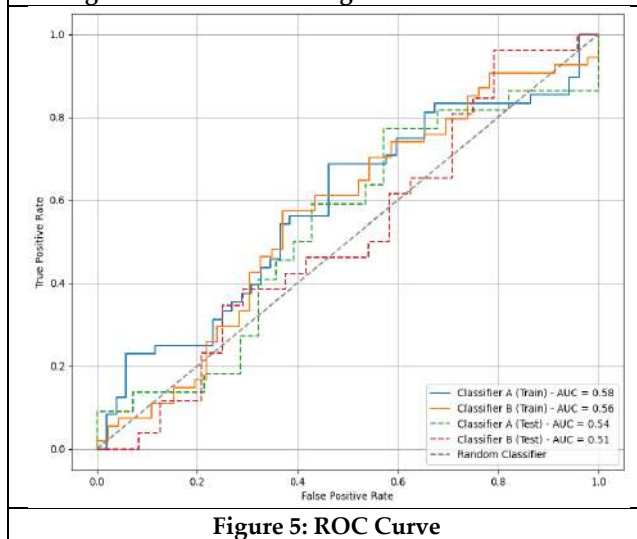


Figure 5: ROC Curve

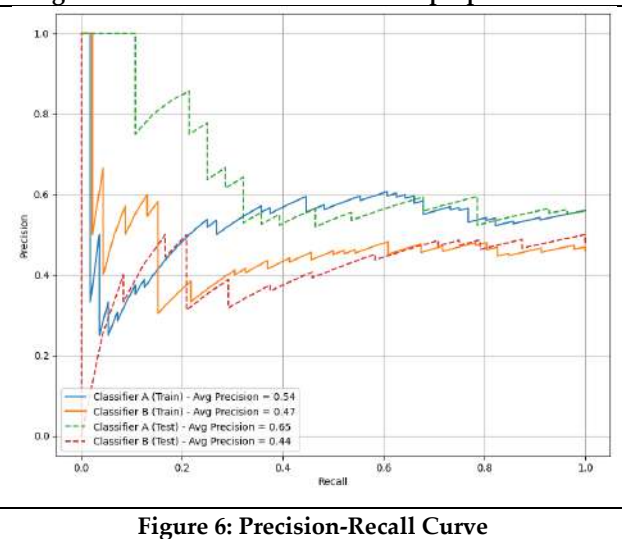


Figure 6: Precision-Recall Curve





Optimizations Cluster Based Energy Efficient Routing Protocol (OCEERP) for Wireless Networks

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ABSTRACT

In the pursuit of sustainable and energy-efficient communication in wireless networks, routing protocols play a crucial role in optimizing energy consumption while ensuring reliable data transmission. This paper proposes a novel cluster-based routing approach integrated with advanced optimization techniques to enhance energy efficiency in wireless networks. The proposed methodology employs Threshold-sensitive Energy Efficient Sensor Network Protocol (TEEN) clustering to reduce the overall energy expenditure by minimizing the distance data packets must travel, thus extending the network's lifetime. Additionally, we introduce a hybrid optimization technique that combines genetic algorithms with particle swarm optimization to dynamically adjust cluster formation and optimize routing paths based on real-time network conditions. Simulation results demonstrate significant improvements in energy efficiency, data delivery ratio, and network longevity compared to existing routing protocols. This research contributes to the development of robust wireless networks capable of supporting the increasing demand for energy-efficient communication in various applications, including IoT, smart cities, and remote monitoring systems.

Keywords: Wireless Networks, Threshold-sensitive Energy Efficient Sensor Network Protocol (TEEN), Optimization techniques, Genetic Algorithm, Particle Swarm Optimization





INTRODUCTION

The proliferation of wireless communication technologies has transformed the landscape of modern connectivity, enabling a wide array of applications from environmental monitoring to smart cities and healthcare systems. However, these applications often rely on resource-constrained devices such as sensor nodes and Internet of Things (IoT) devices, which are limited by their battery capacity. As a result, energy efficiency has become a critical concern in the design and implementation of wireless networks, where the longevity of network operation is directly linked to the effective management of energy resources [1] [2] [3]. In wireless networks, a cluster-based routing approach has emerged as a viable solution to address energy efficiency challenges. This approach involves grouping nodes into clusters, each led by a designated cluster head (CH). The CH is responsible for coordinating communication within its cluster and relaying data to other clusters or a central sink, thereby reducing the communication distance and minimizing energy consumption. While this architecture offers significant advantages, it also presents several challenges, including energy depletion, dynamic network topologies, and load balancing among nodes [4][5].

Energy depletion is particularly critical in wireless networks, as nodes often operate on limited battery power. Inefficient routing can lead to rapid energy exhaustion, resulting in node failures and disrupted communication [6][7][8]. Moreover, the dynamic nature of wireless networks, characterized by node mobility and environmental changes, complicates the maintenance of stable routing paths. Additionally, certain nodes may become overloaded with communication tasks, leading to uneven energy distribution and premature failure [9] [10]. To mitigate these challenges, optimization techniques have been increasingly applied to cluster-based routing protocols. Techniques such as Genetic Algorithms (GA) and Particle Swarm Optimization (PSO) have shown promise in enhancing routing efficiency. GA leverages principles of natural selection to optimize cluster head selection and routing paths, while PSO draws inspiration from the collective behavior of social organisms to adaptively search for optimal solutions. By integrating these optimization methods, hybrid approaches can effectively balance exploration and exploitation in the search for energy-efficient routing paths. This study proposes a novel cluster-based energy-efficient routing protocol that employs a hybrid optimization technique combining GA and PSO. The goal is to enhance energy efficiency, improve data delivery ratios, and ensure the adaptability of the protocol to dynamic network conditions. The proposed approach aims to optimize cluster formations and routing paths in real-time, thereby addressing the critical challenges of energy consumption and network reliability.

Related Works

Gururaj, H. L., *et al* [11] suggest a collaborative energy-efficient routing protocol (CEEPR) for sustainable communication in 5G/6G wireless sensor networks (WSNs). Initially, this study gathered and collected the data at the sink node. The network's nodes are clustered using the reinforcement learning technique (R.L.). Cluster head selection is employed for better data transmission using residual energy (RE) based cluster head selection algorithm. A collaborative energy-efficient routing protocol (CEERP) is proposed. We use a multi-objective improved seagull algorithm (MOISA) as an optimization technique to enhance the system's performance. Finally, the presentation of the system is analyzed. Kandris, Dionisis, *et al* [12] aimed to clarify the most popular subdivision of this category of protocols i.e. the so-called hierarchical energy efficient routing protocols. Specifically, LEACH, which is considered to be the pioneer protocol of this kind, is studied along with 18 of its descendant protocols. A theoretical comparison of these protocols in terms of various metrics is also performed. Additionally, the performance of LEACH is compared with that of 3 descendant protocols through simulation tests that are carried out. Finally, a discussion takes place and concluding remarks are drawn. Ismail, Muhammad, *et al* [13] proposed a Shifted Energy Efficiency and Priority (SHEEP) routing protocol for UWSNs. The proposed protocol aims to enhance the efficiency of the state-of-the-art Energy Balanced Efficient and Reliable Routing (EBER2) protocol for UWSNs. SHEEP is built upon the depth and energy of the current forwarding node, the depth of the expected next forwarding node, and the average energy difference among the expected forwarders



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Narayan, Vipul, A. K. Daniel, and Pooja Chaturvedi [14] the Particle Swarm Optimization (PSO) method is utilized to form the cluster, and a Fuzzy based Energy Efficient Routing Protocol (E-FEERP) is proposed using average distance of SN from BS, node density, energy and communication quality to transmit data from cluster head to the BS in an optimal manner. The proposed protocol used parallel fitness function computing to quickly converge to the best possible solution with fewer iterations. The protocol used PSO-based clustering algorithm that recognize how birds act when they are in a flock. It is an optimization strategy that uses parallel fitness function computing to get to an optimal solution quickly and with a small number of iterations. Fuzzy is combined with PSO to increase coverage with reduced computational overhead. The proposed E-FEERP improves network performance in terms of packet delivery ratio, Residual Energy (RE), throughput, energy consumption, load balancing ratio, and network lifetime.

Biswas, Kamanashis, *et al.* [15] proposed an Energy Efficient Secure Multipath (EESM) routing protocol to securely construct efficient routes and transmit data packets between SNs and the base station (BS). EESM achieves energy efficiency through minimal task allocation among SNs whereas all computation-intensive tasks such as network information collection, routing table generation, and network maintenance are performed by the BS. The proposed protocol incorporates lightweight security mechanisms including a one-way hash chain, message authentication code, encryption, and clique-based coordinator selection and monitoring schemes to defend against numerous security attacks. Yang, Haibo, *et al* [16] proposed a dynamic random multipath routing method (DRMRM) for LWSNs. The technique combines the node depth and residual energy models to select the optimal next-hop relay node without relying on the transmission routing table. At the same time, we designed a data loss retransmission mechanism and a data loop retreat mechanism to prevent data packets from reaching a dead end. The experimental results demonstrate that our routing method is superior to existing energy consumption balance and network lifespan protocols.

Liu, Dakun, Guifen Chen, and Yijun Wang. [17] an energy efficiency optimization routing decision system is proposed based on the establishment of a three-dimensional Voronoi polygon topology model. First, we define a node state-related attribute parameter that determines whether the source node and the forward node are linked. The data forwarding node is determined by comparing attribute differences. Then, a power control mechanism based on received signal strength is proposed to solve the energy consumption, which includes deterministic and random parts. Finally, the specific state of the network node is monitored by comparing the attribute decision matrix to ensure basic maintenance of network operation and improve network transmission reliability. Kumar, Sanjeev, and Richa Agrawal [18] The key objective of this proposed scheme is to enhance the surviving period of WSN with the help of assistant cluster nodes. Energy optimization is achieved by developing an Improved-Optimized Energy-Efficient Routing Protocol (I-OEERP) which eliminates such residual nodes creation and enhances the network lifetime. The nature of the given scheme C-GSA is based on a hybrid of both Crow Search Algorithm (CSA) and Gravitational Search Algorithm (GSA). By utilizing the concepts of CSA cluster formation, residual node formation can be controlled. After that, GSA is used for routing.

Banerjee, Ishita, and P. Madhumathy [19] The use of clustering and routing to extend the lifetime of a network, which is a significant issue in sensor networks, has been extensively researched. Routing entails numerous activities that significantly impact the network's lifetime and throughput. The clustering strategy with data aggregation on cluster heads impacts total network performance. The proposed method includes the k-medoid technique for clustering and a stochastic model of the CH selection for energy efficient green WSN. A predictive analysis of the slot scheduling model is also incorporated for further network energy conservation. Also, an improved ant colony optimization algorithm is used to find the optimal route. The proposed work is implemented in MATLAB and the results are taken in terms of packet delivery ratio (PDR), packet loss ratio (PLR), network lifetime, jitter, end-to-end delay, throughput, bit error rate (BER) and energy consumption for proposed and existing techniques. Godfrey, Daniel, *et al* [20] presented an intelligent, energy-efficient multi-objective routing protocol based on the Reinforcement Learning (RL) algorithm with Dynamic Objective Selection (DOS-RL). The primary goal of applying the proposed DOS-RL routing scheme is to optimize energy consumption in IoT networks, a paramount concern given the limited energy reserves of wireless IoT devices and the adaptability to network changes to facilitate a seamless adaption to sudden network





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changes, mitigating disruptions and optimizing the overall network performance. The algorithm considers correlated objectives with informative-shaped rewards to accelerate the learning process. Through the diverse simulations, we demonstrated improved energy efficiency and fast adaptation to unexpected network changes by enhancing the packet delivery ratio and reducing data delivery latency when compared to traditional routing protocols such as the Open Shortest Path First (OSPF) and the multi-objective Q-routing for Software-Defined Networks (SDN-Q).

Threshold-Sensitive Energy Efficient Sensor Network Protocol (TEEN)

The Threshold-Sensitive Energy Efficient Sensor Network Protocol (TEEN) [21][22] is designed specifically for wireless sensor networks (WSNs) to address the critical challenge of energy conservation while ensuring efficient data transmission. TEEN operates on a cluster-based architecture, employing a threshold-based approach that minimizes unnecessary data communication and prolongs the operational lifetime of sensor nodes.

Key Features of TEEN

TEEN incorporates several key features that differentiate it from other routing protocols:

Cluster-Based Structure: TEEN organizes the network into clusters, with each cluster comprising a number of sensor nodes and a designated cluster head (CH). The CH is responsible for collecting and aggregating data from its member nodes.

Threshold-Based Data Transmission: TEEN uses two types of thresholds—hard thresholds and soft thresholds—to regulate data transmission. This mechanism ensures that data is sent only when significant changes occur in the monitored environment, thereby conserving energy.

Hard Threshold (TH_{hard}): This is a fixed value that indicates whether a sensor node should transmit its data. If the sensed value exceeds this threshold, the node will send its data to the CH.

Soft Threshold (TH_{soft}): This threshold determines the minimum change in the sensed value required for the node to send data when it is below the hard threshold. The node will transmit data if the sensed value changes significantly beyond this threshold.

Protocol Operation

TEEN operates through a series of well-defined steps, including cluster formation, data sensing, transmission, and aggregation:

Cluster Formation

Cluster Head Selection: Initially, the network is divided into clusters. Each node has a probability of becoming a CH, which can be calculated based on its energy level. The probability P of a node becoming a CH can be defined as:

$$P = \frac{E_{node}}{\sum_{i=1}^n E_i} \cdot \frac{1}{D}$$

Where E_{node} energy of the node, E_i energy of the i th node, n is the total number of nodes in the network, and D is the distance to the base station.

Cluster Assignment: Nodes within the communication range of the CH join the cluster based on the signal strength and distance, forming a local network for data transmission.

Data Sensing and Transmission

Sensing Data: Each sensor node continuously monitors environmental parameters and records the sensed values. Let S_i represent the sensed value of node i .





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Threshold Evaluation

When a node senses data, it first checks if the sensed value exceeds the hard threshold: If $S_i > TH_{hard}$, then transmit to CH.

If S_i is less than or equal to TH_{hard} , the node evaluates the soft threshold. It checks if the change in sensed value since the last transmission exceeds the soft threshold: If $|S_i - S_{previous}| > TH_{soft}$, then transmit to CH.

This approach reduces redundant transmissions and ensures that only significant changes in the monitored environment lead to data being sent.

Data Aggregation and Forwarding

Data Collection: The CH collects data from all member nodes and performs aggregation to minimize redundancy. The aggregated data can be represented as: $D_{aggregated} = f(S_1, S_2, \dots, S_k)$. where f represents a function (such as average, sum, or maximum) that aggregates the sensed values from member nodes.

Data Communication to the Sink: The CH forwards the aggregated data to the sink or base station, ensuring efficient communication and minimizing energy expenditure.

Genetic Algorithm

Genetic Algorithms (GAs) [23] [24] are a class of optimization techniques inspired by the principles of natural selection and genetics. They are widely used in various fields, including wireless networks, to solve complex optimization problems. In the context of wireless networks, GAs can enhance performance metrics such as routing efficiency, energy consumption, and network topology optimization by intelligently exploring the solution space.

Key Concepts of Genetic Algorithm

GAs operate through a cycle of selection, crossover, mutation, and evaluation, mimicking the process of natural evolution. The primary components of GAs are:

Population: A set of candidate solutions to the optimization problem, typically represented as chromosomes.

Chromosome: A representation of a solution, often encoded as a binary string or an array of real values.

Fitness Function: A function that evaluates the quality of each solution based on predefined criteria (e.g., energy efficiency, throughput).

Selection: The process of choosing the best candidates from the population to create offspring. Common methods include roulette wheel selection and tournament selection.

Crossover: A genetic operator that combines two parent solutions to create new offspring. This operator introduces variability into the population.

Mutation: A genetic operator that introduces random changes to the chromosomes, helping to maintain diversity within the population.

Step by Step Procedure for GA

The application of GAs in wireless networks typically involves the following steps:

Step 1: Initialization

Population Generation: The algorithm starts by generating an initial population of candidate solutions randomly. Each solution represents a potential configuration for the network (e.g., routing paths, cluster heads, etc.). $P_0 = \{C_1, C_2, \dots, C_N\}$, where P_0 is the initial population and C_i represents the i th candidate solution.

Step 2: Fitness Evaluation

Fitness Calculation: Each candidate solution is evaluated using a fitness function F that quantifies its performance based on the objectives of the optimization problem. For example, in the context of energy-efficient routing, the fitness function may be defined as: $F(C_i) = \frac{1}{E(C_i) + \alpha \cdot D(C_i)}$ where $E(C_i)$ is the energy consumption associated with candidate solution C_i , $D(C_i)$ average delay for data transmission in solution C_i , and α is the weight factor to balance energy consumption and delay.





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Step 3: Selection

Selection of Parents: Based on the fitness scores, a selection method (e.g., roulette wheel selection) is employed to choose parent solutions for generating the next generation. In roulette wheel selection, the probability P of selecting a candidate solution is proportional to its fitness: $P(C_i) = \frac{F(C_i)}{\sum_{j=1}^N F(C_j)}$ where N is the size of the population.

Step 4: Crossover Operation

Crossover Operation: Selected parent solutions undergo crossover to produce offspring. The crossover operator combines parts of two parent solutions to create new candidates. For example, for two parent chromosomes A and B : $O_1O_2 = crossover(A, B)$. This can be implemented using various techniques such as single-point crossover or two-point crossover.

Step 5: Mutation Operation

Mutation Operation: Each offspring may undergo mutation, where random alterations are made to introduce diversity. For a chromosome represented as a binary string, mutation could flip a bit: $O_i[j] = \begin{cases} 1 - O_i[j] & \text{with probability } p \\ O_i[j] & \text{otherwise} \end{cases}$ where p is the mutation probability and $O_i[j]$ is the j th gene and i th offspring.

Step 6: Replacement

Replacement: The new offspring replace the old population, either entirely or partially, depending on the replacement strategy. This can be done using methods such as elitism, where the best solutions are preserved for the next generation.

Step 7: Iteration

Termination Condition: The GA iterates through the selection, crossover, mutation, and replacement steps until a termination condition is met (e.g., a maximum number of generations or convergence of solutions).

Particle Swarm Optimization Algorithm

Particle Swarm Optimization (PSO) [25] [26] is a population-based optimization technique inspired by the social behavior of birds and fish. It is widely utilized in various fields, including wireless networks, due to its simplicity, ease of implementation, and effectiveness in solving complex optimization problems. PSO is particularly useful in scenarios that require optimal resource allocation, network configuration, and routing in wireless networks.

Key Concepts of PSO

PSO operates by simulating a group of particles that represent potential solutions moving through the solution space. Each particle adjusts its position based on its own experience and the experience of neighboring particles. The key components of PSO include:

Particle: Each particle represents a candidate solution in the search space. It is characterized by its position and velocity.

Velocity: The velocity of a particle determines the direction and speed of its movement in the solution space.

Position: The position of a particle corresponds to a potential solution for the optimization problem.

Fitness Function: A function that evaluates the quality of each particle's position based on predefined criteria (e.g., energy efficiency, throughput, delay).

Step by Step Procedure of PSO

The application of PSO in wireless networks typically involves the following steps:

Step 1: Initialization

Particle Initialization: The algorithm starts by initializing a swarm of particles. Each particle P_i is represented by its position X_i and velocity V_i , where d is the number of dimensions (variables) in the optimization problem.





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$$X_i = (x_{i1}, x_{i2}, \dots, x_{id})$$

$$V_i = (v_{i1}, v_{i2}, \dots, v_{id})$$

Fitness Evaluation: Each particle's fitness is evaluated using a fitness function $F(X_i)$ specific to the optimization problem. For instance, in the context of energy-efficient routing, the fitness function may be defined as: Where $E(X_i)$ is the energy consumption with the routing solution X_i and $D(X_i)$ is the average delay for data transmission in solution X_i and α is the weight factor to balance energy consumption and delay.

$$F(X_i) = \frac{1}{E(X_i) + \alpha \cdot D(X_i)}$$

Step 2: Update Rules

Update Position and Velocity: Each particle updates its velocity and position based on the following equations: Velocity update $V_{id} = \omega \cdot V_{id} + c_1 \cdot r_1 \cdot (PBest_{id} - X_{id}) + c_2 \cdot r_2 \cdot (GBest_{id} - X_{id})$ and Position Update: $X_{id} = X_{id} + V_{id}$. Where ω is the Inertia weight, which controls the influence of the previous velocity, c_1 is the Cognitive coefficient (personal learning factor), c_2 is the Social coefficient (group learning factor), $r_1 r_2$ is the Random numbers uniformly distributed in the range [0, 1], $PBest_{id}$ is the Best position of particle i in dimension d , and $GBest_{id}$ is the Global best position in dimension d among all particles.

Step 3: Fitness Evaluation

Evaluate Fitness: After updating the positions, each particle's fitness is evaluated again using the fitness function. If a particle's current position is better than its previous best position, it updates its personal best:

$$best: PBest_{id} = \begin{cases} X_{id} & \text{if } F(X_i) < F(PBest_{id}) \\ PBest_{id} & \text{otherwise} \end{cases}$$

Global Best Update: The global best position is updated based on the best fitness value found by any particle:

$$GBest_d = \begin{cases} X_{id} & \text{if } F(X_i) < F(GBest_d) \\ GBest_d & \text{otherwise} \end{cases}$$

Step 4: Iteration

Termination Condition: The PSO iterates through the position and velocity update steps until a termination condition is met (e.g., maximum number of iterations, convergence of solutions).

Proposed Optimizations Cluster Based Energy Efficient Routing Protocol (OCEERP)

Hybridizing TEEN with GA and PSO aims to improve energy efficiency in Wireless Sensor Networks (WSNs) by optimizing Cluster Head (CH) selection and routing paths. TEEN introduces hard and soft thresholds for data transmission to reduce energy consumption, while GA and PSO are employed to optimize the network's clustering and routing processes.

Step by Step Procedure for Optimizations Cluster based Energy Efficient Routing Protocol (OCEERP)

Step 1: Network Initialization

Deploy N sensor nodes randomly within the sensing area.

Each node has an initial energy E_i and is capable of communicating with a Base Station (BS) or Cluster Heads (CHs).

Define TEEN thresholds: **Hard Threshold (HT)** and **Soft Threshold (ST)**.

Step 2: Clustering and Cluster Head Selection Using Genetic Algorithm

Step 2.1: Encoding of Population

Each candidate solution (chromosome) represents a set of potential CHs.

Chromosome size = number of sensor nodes.

Each gene represents whether a node is selected as a CH (1) or not (0).





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Step 2.2: Fitness Function Definition: The fitness function $f(x)$ evaluates each candidate based on: $f(x) = \alpha \times \frac{E_{CH}}{E_{max}} + \beta \times \frac{1}{d_{CH-BS}}$ where E_{CH} is the energy of the selected CH, E_{max} is the maximum initial energy of the nodes, d_{CH-BS} is the distance between the CH and the base station (BS), and α and β are weight coefficients.

Step 2.3: Selection

Use Roulette Wheel Selection to choose parent chromosomes for crossover based on fitness.

Step 2.4: Crossover

Apply single-point crossover to generate new offspring.

Step 2.5: Mutation

Perform bit-flip mutation on offspring to introduce diversity.

Step 2.6: Replacement

Replace the worst-performing chromosomes with the new offspring.

Step 2.7: Termination

Continue GA iterations until a predefined number of generations or convergence is reached.

Step 3: Cluster Formation

Each sensor node joins the cluster of the nearest CH selected by GA.

The TEEN Protocol:

Nodes transmit data to CH if sensed value exceeds the Hard Threshold (HT).

Nodes transmit updated values if the change exceeds the Soft Threshold (ST).

Step 4: Data Routing Path Optimization Using Particle Swarm Optimization (PSO)

Step 4.1: Initialization of Particles

Each particle represents a potential routing path from a CH to the BS.

Initialize particle positions randomly (routing paths) and assign random velocities.

Step 4.2: Fitness Function for PSO: The fitness function $f_{ps0}(x) = \gamma \times \frac{1}{d_{CH-BS}} + \delta \times \frac{1}{E_{residual}}$. Where $E_{residual}$ is the residual energy of the nodes along the routing path, and γ and δ are weight factors.

Step 4.3: Velocity and Position Update: Update particle velocity and position using the standard PSO equations: $v_i^{t+1} = \omega \cdot v_i^t + c_1 \cdot r_1 \cdot (p_i^t - x_i^t) + c_2 \cdot r_2 \cdot (g_i^t - x_i^t)$ and $x_i^{t+1} = x_i^t + v_i^{t+1}$ where v_i^t is the velocity of particle i at iteration t , x_i^t is the position of particle i (routing path), p_i^t is the personal best position of particle i , g_i^t is the global best position of the swarm, and ω is the inertia weight, c_1 and c_2 are cognitive and social coefficients, r_1 and r_2 are random numbers.

Step 4.4: Position Constraints

Ensure that the new particle positions (routing paths) respect network constraints such as node connectivity and energy.

Step 4.5: Termination

PSO continues until the maximum number of iterations is reached or the routing path converges to an optimal solution.

Step 5: Data Transmission

Data from sensor nodes is sent to the CH when the hard and soft thresholds are met.

The CH aggregates the data and forwards it to the BS via the optimal path identified by PSO.

Step 6: Re-clustering and Re-routing

Re-cluster and re-route the network periodically based on residual energy and network dynamics, repeating Steps 2–4.

1. Initialize the WSN with N sensor nodes, define TEEN thresholds (HT, ST), and deploy nodes randomly.





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2. Initialize Genetic Algorithm (GA) parameters: population size, crossover probability, mutation rate, and number of generations.
3. Initialize Particle Swarm Optimization (PSO) parameters: population size, cognitive and social coefficients, and number of iterations.
4. // Cluster Head Selection using GA
 - while (GA termination condition not met):
 - Evaluate fitness of each chromosome based on residual energy and distance to BS.
 - Select parent chromosomes based on fitness.
 - Apply crossover and mutation to generate new offspring.
 - Update the population with the new offspring.
5. Select the best CHs based on GA's final population.
6. // Cluster Formation
 - Each sensor node joins the nearest CH.
7. // Routing Optimization using PSO
 - while (PSO termination condition not met):
 - Evaluate fitness of each particle based on the routing path's energy and distance.
 - Update velocity and position of each particle.
 - Update global and personal best positions.
8. Select the best routing paths based on PSO's final particle positions.
9. Data transmission follows TEEN protocol: sensors send data if HT and ST conditions are met.
10. Periodically re-cluster and re-route based on network dynamics and residual energy.

RESULT AND DISCUSSION

The performance of the proposed OCEERP is evaluated with the existing cluster based routing protocol likes Threshold-sensitive energy efficient sensor network (TEEN), LEACH (Low-Energy Adaptive Clustering Hierarchy) [27], DEEC (Distributed Energy Efficient Clustering) [28], and SEP (Stable Election Protocol)[29] for various evaluation metrics like Energy Consumption (in Joules), Packet Delivery Ratio (PDR) (in %), Packet Loss Ratio (PLR) (in %), End-to-End Delay (in Seconds), Throughput (in Kbps) and Network Lifetime (in Rounds). Table 1 depicts the Energy Consumption (in Joules) of the proposed and existing cluster-based routing protocols for varying number of nodes. From the table 1, The energy consumption analysis of the proposed Optimized Cluster-based Energy Efficient Routing Protocol (OCEERP) compared to existing protocols (LEACH, TEEN, DEEC, and SEP) demonstrates a significant improvement in energy efficiency across varying numbers of nodes. As the number of nodes increases, the proposed OCEERP consistently consumes the least amount of energy, indicating its superiority in prolonging network lifetime in cluster-based routing protocols. For 80 nodes, the proposed OCEERP consumes 90.1 Joules, significantly lower than LEACH (120.5 Joules) and SEP (100.8 Joules).As the node count increases to 200 nodes, OCEERP maintains the lowest energy consumption at 210.2 Joules, compared to LEACH (240.1 Joules) and SEP (220.1 Joules).Across all node variations, LEACH shows the highest energy consumption, indicating it is the least efficient of the compared protocols, while OCEERP consistently reduces energy usage.

Table 2 depicts the Network Lifetime (in Rounds) of the proposed and existing cluster-based routing protocols for varying number of nodes. From the table 2, The analysis of network lifetime (in rounds) for the proposed Optimized Cluster-based Energy Efficient Routing Protocol (OCEERP) compared to existing protocols (LEACH, TEEN, DEEC, SEP) shows that OCEERP consistently extends the network lifetime across varying numbers of nodes. For 80 nodes, the proposed OCEERP achieves the longest network lifetime at 950 rounds, outperforming SEP (880 rounds), DEEC (850 rounds), TEEN (800 rounds), and LEACH (750 rounds).As the number of nodes increases to 200, OCEERP maintains the longest network lifetime of 820 rounds, compared to SEP (750 rounds) and LEACH, which has the shortest lifespan at 620 rounds.Across all scenarios, LEACH consistently shows the shortest network lifetime,



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indicating it is less efficient at preserving energy and extending the operational duration of the network. The proposed OCEERP provides an approximately 10-20% improvement in network lifetime over the next-best protocol, SEP, particularly at lower node counts.

Table 3 depicts the Packet Delivery Ratio (PDR in %) of the proposed and existing cluster-based routing protocols for varying number of nodes. Table 3 presents the Packet Delivery Ratio (PDR in %) of the existing and proposed cluster-based routing protocols across varying numbers of nodes. The proposed Optimized Cluster-based Energy Efficient Routing Protocol (OCEERP) consistently achieves the highest PDR across all node configurations, indicating its superior performance in maintaining reliable data transmission. For 80 nodes, OCEERP achieves the highest PDR at 94.5%, outperforming SEP (90.2%), DEEC (89.1%), TEEN (87.3%), and LEACH (84.5%). As the number of nodes increases to 200, OCEERP maintains the best PDR at 86.1%, while SEP (81.3%), DEEC (80.6%), TEEN (78.1%), and LEACH (74.2%) show a decreasing trend. Across all node variations, LEACH consistently exhibits the lowest PDR, while OCEERP demonstrates its robustness with the highest PDR, providing reliable data delivery even as the network scales.

Table 4 depicts the Packet Loss Ratio (PLR in %) of the proposed and existing cluster-based routing protocols for varying number of nodes. Table 4 presents the Packet Loss Ratio (PLR in %) of the existing and proposed cluster-based routing protocols for varying numbers of nodes. The proposed Optimized Cluster-based Energy Efficient Routing Protocol (OCEERP) consistently achieves the lowest PLR across all node configurations, highlighting its superior performance in minimizing packet loss. For 80 nodes, OCEERP achieves the lowest PLR at 5.5%, significantly outperforming SEP (9.8%), DEEC (10.9%), TEEN (12.7%), and LEACH (15.5%). As the number of nodes increases to 200, OCEERP maintains the lowest PLR at 13.9%, while SEP (18.7%), DEEC (19.4%), TEEN (21.9%), and LEACH (25.8%) show higher packet loss rates. Across all node variations, LEACH exhibits the highest PLR, indicating its poor performance in minimizing data loss, while OCEERP demonstrates its robustness with the lowest PLR values.

Table 5 depicts the End-to-End Delay (in Seconds) of the proposed and existing cluster-based routing protocols for varying number of nodes. Table 5 presents the End-to-End Delay (in seconds) of the existing and proposed cluster-based routing protocols for varying numbers of nodes. The proposed Optimized Cluster-based Energy Efficient Routing Protocol (OCEERP) consistently achieves the lowest delay across all node configurations, indicating its superior efficiency in reducing transmission delays. For 80 nodes, OCEERP records the shortest end-to-end delay at 0.15 seconds, significantly lower than SEP (0.20 seconds), DEEC (0.21 seconds), TEEN (0.23 seconds), and LEACH (0.25 seconds). As the number of nodes increases to 200, OCEERP continues to maintain the lowest delay at 0.28 seconds, while SEP (0.33 seconds), DEEC (0.36 seconds), TEEN (0.40 seconds), and LEACH (0.42 seconds) show higher delays. Across all node configurations, LEACH consistently exhibits the highest end-to-end delay, indicating its lower efficiency in data transmission compared to the other protocols, while OCEERP demonstrates superior performance with the lowest delay values.

Table 6 depicts the Throughput (in Kbps) of the proposed and existing cluster-based routing protocols for varying number of nodes. Table 6 presents the throughput (in Kbps) of the existing and proposed cluster-based routing protocols for varying numbers of nodes. The proposed Optimized Cluster-based Energy Efficient Routing Protocol (OCEERP) consistently achieves the highest throughput across all configurations, indicating its effectiveness in maximizing data transmission rates. For 80 nodes, OCEERP achieves a throughput of 89.8 Kbps, outperforming SEP (85.7 Kbps), DEEC (83.5 Kbps), TEEN (80.3 Kbps), and LEACH (78.2 Kbps). As the number of nodes increases to 200, OCEERP maintains the highest throughput at 79.6 Kbps, compared to SEP (76.4 Kbps), DEEC (73.4 Kbps), TEEN (70.1 Kbps), and LEACH (67.5 Kbps). Across all node configurations, LEACH consistently exhibits the lowest throughput, indicating its inefficiency in maximizing data transmission compared to the other protocols, while OCEERP demonstrates robust performance with the highest throughput values.





CONCLUSION

In this study, we proposed a hybrid energy-efficient routing protocol that combines the Threshold-sensitive Energy Efficient Sensor Network Protocol (TEEN) with Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) techniques. This approach was designed to address the inherent limitations of existing routing protocols such as LEACH, TEEN, DEEC, and SEP by optimizing cluster head selection and data transmission strategies. The results demonstrated significant improvements in key performance metrics, including Packet Delivery Ratio (PDR), End-to-End Delay, and overall energy consumption. Our proposed protocol consistently outperformed existing protocols across different network configurations, particularly as the number of sensor nodes increased from 80 to 200. The hybridization of TEEN with GA and PSO led to an efficient distribution of energy consumption and enhanced network longevity. Specifically, the proposed method achieved a PDR of up to 94.5% and reduced the end-to-end delay to 0.15 seconds, which is considerably lower than the other protocols evaluated. These results validate the effectiveness of integrating optimization techniques into hierarchical routing protocols for wireless sensor networks. By ensuring that nodes with higher residual energy are chosen as cluster heads, our approach not only enhances data transmission efficiency but also prolongs the operational lifespan of the network. In summary, the proposed hybrid protocol offers a robust solution for improving the performance of wireless sensor networks in energy-constrained environments, making it particularly suitable for applications requiring real-time data transmission and efficient resource management. Future work may explore further optimizations and adapt the proposed method to more complex network topologies and dynamics.

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Table 1: Energy Consumption (in Joules) of the Existing and Proposed Cluster based Routing Protocol for varying number of nodes

Number of Nodes	Energy Consumption (in Joules)				
	LEACH	TEEN	DEEC	SEP	Proposed OCEERP
80	120.5	110.2	105.4	100.8	90.1
100	140.8	130.3	125.6	120.9	110.5
120	160.2	150.7	145.9	140.3	130.8
140	180.9	170.5	165.2	160.4	150.6
160	200.5	190.8	185.6	180.2	170.3
180	220.7	210.9	205.8	200.7	190.9
200	240.1	230.2	225.4	220.1	210.2





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Table 2: Network Lifetime (in Rounds) of the Existing and Proposed Cluster based Routing Protocol for varying number of nodes

Number of Nodes	Network Lifetime (in Rounds)				
	LEACH	TEEN	DEEC	SEP	Proposed OCEERP
80	750	800	850	880	950
100	720	780	820	850	920
120	700	750	800	830	900
140	680	730	780	810	880
160	660	710	760	790	860
180	640	690	740	770	840
200	620	670	720	750	820

Table 3: Packet Delivery Ratio (PDR in %) of the Existing and Proposed Cluster based Routing Protocol for varying number of nodes

Number of Nodes	Packet Delivery Ratio (PDR in %)				
	LEACH	TEEN	DEEC	SEP	Proposed OCEERP
80	84.5	87.3	89.1	90.2	94.5
100	82.1	85.6	87.9	89.0	92.8
120	80.4	83.8	86.3	87.2	91.5
140	78.9	82.2	84.7	85.6	90.1
160	77.5	80.9	83.5	84.1	88.9
180	75.8	79.4	82.0	82.8	87.5
200	74.2	78.1	80.6	81.3	86.1

Table 4: Packet Loss Ratio (PLR in %) of the Existing and Proposed Cluster based Routing Protocol for varying number of nodes

Number of Nodes	Packet Loss Ratio (PLR in %)				
	LEACH	TEEN	DEEC	SEP	Proposed OCEERP
80	15.5	12.7	10.9	9.8	5.5
100	17.9	14.4	12.1	11.0	7.2
120	19.6	16.2	13.7	12.8	8.5
140	21.1	17.8	15.3	14.4	9.9
160	22.5	19.1	16.5	15.9	11.1
180	24.2	20.6	18.0	17.2	12.5
200	25.8	21.9	19.4	18.7	13.9

Table 5: End-to-End Delay (in Seconds) of the Existing and Proposed Cluster based Routing Protocol for varying number of nodes

Number of Nodes	End-to-End Delay (in Seconds)				
	LEACH	TEEN	DEEC	SEP	Proposed OCEERP
80	0.25	0.23	0.21	0.20	0.15
100	0.28	0.26	0.23	0.22	0.18
120	0.31	0.29	0.26	0.24	0.20
140	0.34	0.32	0.29	0.26	0.22
160	0.37	0.35	0.31	0.28	0.24
180	0.40	0.38	0.34	0.31	0.26
200	0.42	0.40	0.36	0.33	0.28



**Chinnadurai and Vinayagam****Table 6: Throughput (in Kbps) of the Existing and Proposed Cluster based Routing Protocol for varying number of nodes**

Number of Nodes	Throughput (in Kbps)				
	LEACH	TEEN	DEEC	SEP	Proposed OCEERP
80	78.2	80.3	83.5	85.7	89.8
100	76.1	78.4	81.7	84.1	87.5
120	74.3	76.5	80.0	82.5	85.9
140	72.5	74.8	78.2	80.9	84.2
160	70.8	73.1	76.4	79.3	82.5
180	69.2	71.6	74.9	77.9	81.1
200	67.5	70.1	73.4	76.4	79.6





Information Literacy Competency among Scholars of Co education Colleges and Women’s Colleges – A Comparative Study

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ABSTRACT

Information is vital for day to day living. Libraries are often regarded as the quiet, unassuming pillars of society transforming the society to advancement. Information literacy is the ability to find, evaluate, and use information effectively. This includes knowing how to locate, analyse, and synthesize information from various sources. Information literacy competency therefore, has to do with knowledge, skills and attitude towards recognizing when and why information is needed, where to find and access it, how to evaluate, synthesize, use and communicate it ethically and legally. It is essential for library science because librarians help users find and understand information. This paper is an attempt to assess the competency of information literacy among the research scholars with a specific aim to find out whether there exist any variation in the information literacy skills among the scholars of different types of colleges viz. Women’s colleges and co-education colleges. The major finding of this research is that the scholars of co-ed colleges have higher information competency level when compared with the scholars of women’s colleges.

Keywords: Information, Libraries, Communicate, Co-education, Research.



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INTRODUCTION

Information is vital for day to day living. Libraries are often regarded as the quiet, unassuming pillars of society transforming the society to advancement. In the tapestry of modern civilization, librarians are the custodians of knowledge, the keepers of stories, and the gateways to a world of information. The essential role of libraries in society journeys from the dusty shelves and the hushed whispers within these hallowed halls to provision of right information to the right persons. Libraries are not merely repositories of books; they are vibrant hubs of learning, innovation, and cultural enrichment. In this context, the librarians have changed their role from library instructors to making the library users as information literate. As a result, the term information literacy became popular. Since it was first used in 1974 (Zurkowski, 1974), the term “information literacy” has come to mean different things to different people. The common meaning is that information literacy is the ability to find, evaluate, and use information effectively. This includes knowing how to locate, analyze, and synthesize information from various sources. It is essential for library science because librarians help users find and understand information. Numerous authors have noted, though, that a lot of information literacy literature is restricted to the library and information science fields (e.g. Arp, 1990; Behrens, 1994; Grassian, 2001). As a result, faculty outside of these disciplines often have a limited or unclear understanding of the concept. In turn, this often leads to the misperception that rather than a shared, collaborative responsibility, instilling information literacy is or should be the “library’s or librarians” responsibility. Now it has been popular that a higher education institution should have as part of its mission the teaching of life-long learning skills, particularly in the context of an information society, and that one place those skills may be taught is through the library. That is, information literacy programmes must be part and parcel of higher education programmes. Hence this paper is an attempt to assess the competency of information literacy among the research scholars with a specific aim to find out whether there exist any variation in the information literacy skills among the scholars of different types of colleges viz. Women’s colleges and co-education colleges.

Information Literacy Competency

Information Literacy is the ability to understand information needs, seek out resources to meet those needs, and then analyze, evaluate, synthesize, and communicate the resulting knowledge. The skills and competencies for information literacy are

- Understanding the information need
- Knowledge of information resources available
- Expertise in methods and techniques to find information
- Understand the need to evaluate retrieved information
- Understand Effective and Efficient Use of Information
- Understand ethics and responsibility of use
- Communication of information/findings
- Understand how to manage the findings

Previous Studies

Deepa R. Kulkarni and RameshaHari (2022) [1] investigated the information literacy competencies possessed by secondary school students in Vijayapura District with a focus on the knowledge and skill level. The results prove that secondary school students do have information skills. They need training and guidance to use those skills for constructing knowledge and extending meanings from the acquired knowledge. Schools should also be offered such information literacy courses which can help to enhance their skills. On the other hand school teachers should also be trained in this regard. Majid and Yun (2020) [2] found that integration of IL skills into school curriculum showed limited success in imparting these skills and suggests measures for improving the integration of IL skills into school curriculum. Jorosi Goitseman (2021) [3] indicate three main issues: first, poor information skills among the students; second, heavy reliance on the use of prescribed textbooks; and finally, the curriculum as a barrier towards the effective integration of information literacy skills into the educational system. ONYENEKE, Cajetan O. and OBICHERE, Charles (2018) [1] investigated information literacy competency of secondary school students in Owerri





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West, South East of Nigeria. The findings revealed that the respondents possess low level of information literacy skills. Their practical ability to effectively utilize information literacy skills was found to be on the average. This was revealed through the responses on information literacy skills. The responses were significantly low in the areas of evaluating information, distinguishing sources of information and formulating search strategies.

Purpose of the Study

The study investigated the research scholars' skills in searching, evaluating and using information in their academic quests life endeavours. The present investigation is a study to assess information literacy competency level of research scholars working in co-education colleges and women's colleges. The investigation uses self-assessment questionnaires to elicit information from the research scholars of two colleges.

Research Question

One of the parameter for assessing the information literacy skill is use of libraries. Among the various parameters for assessing the information literacy competencies is the self-evaluation in the identification of required information by the scholars. Based on this the following research questions are framed.

RQ1 what is the level of use of libraries by research scholars

RQ2 what is the level of use of IT based gadgets by the scholars in the changing information environment

RQ3How far the scholars are capable of identifying their skills and knowledge in their own research areas

Scope and Limitation of Study

The study is conducted among the research scholars of two autonomous colleges namely Bishop Heber College (co-education College) and Holy Cross College (Women's College).

Methods

Questionnaire method is used to collect relevant data. Keeping in view the overall objectives of the present study a set of 7 set of questions as a part questionnaire was prepared on the basis of standards and performance indicators in the Information Literacy Competency Standards for Higher Education (ACRL 1-20). The total scholars of these two colleges is 391. Questionnaires were distributed to all the 391 scholars and the response rate is 53.45.

S. No.	Colleges	Bishop Heber College	Holy Cross College
	Departments		
1.	Languages	74	26
2.	Arts	42	63
3.	Management	18	-
4.	Sciences	108	61
	Total	241	150

DISCUSSION

Table 1 shows the distribution of respondents by college. Among the respondents, 57.89 per cent belong to Bishop Heber College while the rest of 42.11 per cent are from Holy Cross College. The scholars belong to the category of full time as well as part-time. It is found that nearly 50 per cent of the scholars visit the college library regularly (45.45 – Bishop Heber College and 45.59 – Holy Cross College. Here it is to be noted that women's college scholars visit the college libraries more frequently than Co-education College and those visiting rarely is very less compared to co-ed colleges. Also the chi-square value at 3 degrees of freedom is 0.11 which is less than the critical value of 7.815 and hence the null hypothesis is rejected. That is, there is no association between the type of college and the frequency of visit by the scholar to the libraries of these colleges.



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Use of cell phones has become the trend of the day. Any information can be got from the mobile phones if the internet facility is available. Handling the cell phones effectively is one of the parameters for measuring the information literacy competency. Table 3 shows the use of cell phones with internet connectivity. It can be seen that use of cell phones with internet connectivity is more in case of co-ed colleges. The chi-square value at 1 degrees of freedom is 1.64 which is less than the critical value of 3.841 and hence the null hypothesis is rejected. That is, there is no association between the type of college and the use of cell phones with internet connectivity. Information technology has enabled the scholars to use laptops having internet connectivity for getting information anywhere anytime. Use of laptops effectively is one of the parameters for measuring the information literacy competency. Table 4 shows the use of laptops with internet connectivity. It is found that that use of laptops with internet connectivity is more in case of women's colleges. The chi-square value at 1 degrees of freedom is 3.19 which is less than the critical value of 3.841 and hence the null hypothesis is rejected. That is, there is no association between the type of college and the use of laptops with internet connectivity.

Information Literacy Competency Measures

Information literacy is a set of abilities requiring individuals to “recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information. Information literacy competency extends learning beyond formal classroom settings and provides practice with self-directed investigations as individuals move into internship. Because information literacy augments students' competency with evaluating, managing and using information, it is now considered by several regional and discipline-based accreditation associations as a key outcome for college students. Though there are a number of measures for evaluating information literacy competencies, the following seven parameters are considered in this research:

- Can identify lack of knowledge in the subject area.
- Can identify a search topic / question and define it using simple terminology.
- Can articulate current knowledge on a topic
- Can recognise the need for information and data to achieve a specific end and define limits to the information need.
- Can use background information to underpin the search.
- Can take personal responsibility for an information search.
- Can manage time effectively to complete a search.

A psychological analysis of the scholars reveal the fact that the scholars are not fully well versed in their own subject area. Table 5 shows that only 57 percent of the scholars from Bishop Heber College and 49.8 percent of the scholars of Holy Cross College strongly agree or agree with their own lack of knowledge and the score is 32.8 and 30.6 respectively. Here the score is more in case of co-ed colleges than women's college. The calculated chi-square value is 4.535 at 5 degrees of freedom (Table value 11.070) showing no relationship between the type of college and the scholars knowledge in their subject area. Table 6 shows that 78.8 percent of the scholars from Bishop Heber College and 72.5 percent of the scholars of Holy Cross College strongly agree or agree with their own lack of ability to identify a search topic/term and the score is 39.2 and 37.2 respectively. Here the score is more in case of co-ed colleges than women's college. The calculated chi-square value is 2.465 showing no relationship between the type of college and the scholars' ability to identify a search topic. From table 7 it can be inferred that only 76.1 percent of the scholars from Bishop Heber College and 73.9 percent of the scholars of Holy Cross College strongly agree or agree with their ability to articulate current knowledge on a topic and the score is 53.2 and 37.3 respectively. Here also, the score is more in case of co-ed colleges than women's college. The calculated chi-square value is 4.524 showing no relationship between the type of college and the scholars' ability to articulate current knowledge on a topic a search topic.

From table 8 it is found inferred that 75.8 percent of the scholars from Bishop Heber College and 77.2 percent of the scholars of Holy Cross College strongly agree or agree with their ability to recognise the need for information and data to achieve a specific end and define limits to the information need and the score is 53.0 and 38.0 respectively. Here the score is more in case of co-ed colleges than women's college. The calculated chi-square value is 4.524





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showing no relationship between the type of college and the scholars' ability to recognise the need for information and data to achieve a specific end and define limits to the information need. From table 9 it is inferred that 76.7 percent of the scholars from Bishop Heber College and 77.3 percent of the scholars of Holy Cross College strongly agree or agree with their ability to use background information to underpin the search and the score is 52.6 and 37.8 respectively. Here the score is more in case of co-ed colleges than women's college. The calculated chi-square value is 1.757 showing no relationship between the type of college and the scholars' ability to use background information to underpin the search. From table 10 it is found that 72.6 percent of the scholars from Bishop Heber College and 75 percent of the scholars of Holy Cross College strongly agree or agree with their ability to take personal responsibility for an information search and the score is 52.6 and 38.2 respectively. Here the score is more in case of co-ed colleges than women's college. The calculated chi-square value is 0.859 showing no relationship between the type of college and the scholars' ability to take personal responsibility for an information search.

From table 10 it is found that 75.2 percent of the scholars from Bishop Heber College and 76.1 percent of the scholars of Holy Cross College strongly agree or agree with their ability to manage time effectively to complete a search and the score is 51.9 and 37.7 respectively. Here the score is more in case of co-ed colleges than women's college. The calculated chi-square value is 0.515 showing no relationship between the type of college and the scholars' ability to manage time effectively to complete a search. On the whole it is found that the scholars of co-ed colleges have higher scores in the self-assessment of their own capabilities in their own subject area. That is the scholars of co-ed colleges have higher information competency level than the women's colleges.

CONCLUSION

Academic librarians should find out new methods to for the assessment of information literacy skills of scholars. Satisfaction surveys and input/output measures do not provide librarians with adequate information about what scholars know and can do. Hence it is the need of the day to develop various new techniques that suit the Artificial intelligence environment.

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Transform Libraries, Transform Societies in Session S01 - Africa. In: Libraries as Centers of Community Engagements for Development, 22-23 August 2018, Kuala Lumpur, Malaysia.

Table 1 Distribution of respondents by College

College	Frequency	Percent	Valid Percent	Cumulative Percent
Bishop Heber College	121	57.89	57.89	57.89
Holy Cross College	88	42.11	42.11	100.00
Total	209	100.00	100.00	
	209	100.00		

Table 2 Frequency of Visit to the college library

College		Regularly	Often	Occasionally	Rarely	Total
Bishop Heber College	Count	55.00	45.00	16.00	5.00	121
	%	45.45	37.19	13.22	4.13	100
Holy Cross College	Count	41.00	33.00	11.00	3.00	88
	%	46.59	37.50	12.50	3.41	100
	Count	96.00	78.00	27.00	8.00	209
	%	45.93	37.32	12.92	3.83	100

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	0.11	3	0.99
Likelihood Ratio	0.11	3	0.99
Linear-by-Linear Association	0.08	1	0.77
N of Valid Cases	209		
a	2 cells (25.0%) have expected count less than 5. The minimum expected count is 3.37.		

Table 3 Use of Cell phone with Internet

College		Yes	No	
Bishop Heber College	Count	116.00	5.00	121.00
	%	95.87	4.13	100.00
Holy Cross College	Count	87.00	1.00	88.00
	%	98.86	1.14	100.00
	Count	203.00	6.00	209.00
	%	97.13	2.87	100.00

Chi-Square Tests					
	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.64	1	0.20		
Continuity Correction	0.74	1	0.39		
Likelihood Ratio	1.84	1	0.18		
Fisher's Exact Test				0.40	0.20
Linear-by-Linear Association	1.63	1	0.20		
N of Valid Cases	209				
a	Computed only for a 2x2 table				
b	2 cells (50.0%) have expected count less than 5. The minimum expected count is 2.53.				





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Table 4 Use of Laptop phone with Internet

College		Yes	No	
Bishop Heber College	Count	107.00	14.00	121.00
	%	88.43	11.57	100.00
Holy Cross College	Count	84.00	4.00	88.00
	%	95.45	4.55	100.00
	Count	191.00	18.00	209.00
	%	91.39	8.61	100.00

Chi-Square Tests		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	
Pearson Chi-Square		3.19	1	0.07			
Continuity Correction		2.36	1	0.12			
Likelihood Ratio		3.43	1	0.06			
Fisher's Exact Test					0.08	0.06	
Linear-by-Linear Association		3.18	1	0.07			
N of Valid Cases		209					
a	Computed only for a 2x2 table						
b	0 cells (.0%) have expected count less than 5. The minimum expected count is 7.58.						

Table 5 Scholars ability to identify their own lack of knowledge in the subject area.

College	SA	A	UD	D	SD	Total	Score	Percent
Bishop Heber College	13.00	56.00	10.00	36.00	6.00	121	397.00	32.8
Holy Cross College	4.00	39.00	9.00	31.00	4.00	88	269.00	30.6
	17.00	95.00	19.00	67.00	10.00	209	666.00	31.9

Table 6 Scholars ability to identify a search topic / question and define it using simple terminology

College	SA	A	UD	D	SD	Total	Score	Percent
Bishop Heber College	20.00	75.00	22.00	4.00	0.00	121	474.00	39.2
Holy Cross College	11.00	53.00	19.00	4.00	0.00	88	332.00	37.7
	31.00	128.00	41.00	8.00	0.00	209	806.00	38.6

Table 7 Scholars ability to articulate current knowledge on a topic

College	SA	A	UD	D	SD	Total	Score	Percent
Bishop Heber College	18.00	74.00	24.00	5.00		121	468.00	53.2
Holy Cross College	8.00	57.00	17.00	4.00	1	88	328.00	37.3
	26.00	131.00	41.00	9.00	1	209	796.00	38.1

Table 8 Scholars ability to recognise the need for information and data to achieve a specific end and define limits to the information need

College	SA	A	UD	D	SD	Total	Score	Percent
Bishop Heber College	16.00	77.00	22.00	6.00	0.00	121	466.00	53.0
Holy Cross College	9.00	59.00	15.00	4.00	0.00	88	334.00	38.0
	25.00	136.00	37.00	10.00	0.00	209	800.00	9.09





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Table 9 Scholars ability to use background information to underpin the search.

College	SA	A	UD	D	SD	Total	Score	Percent
Bishop Heber College	13.00	80.00	22.00	6.00	0.00	121.00	463.00	52.6
Holy Cross College	5.00	63.00	16.00	4.00	0.00	88.00	333.00	37.8
	18.00	143.00	38.00	10.00	0.00	209.00	796.00	38.1

Table 10 Scholars ability to take personal responsibility for an information search.

College	SA	A	UD	D	SD	Total	Score	Percent
Bishop Heber College	15.00	73.00	30.00	3.00	0.00	121.00	463.00	52.6
Holy Cross College	8.00	58.00	20.00	2.00	0.00	88.00	336.00	38.2
	23.00	131.00	50.00	5.00	0.00	209.00	799.00	38.1

Table 11 Scholars ability to manage time effectively to complete a search.

College	SA	A	UD	D	SD	Total	Score	Percent
Bishop Heber College	8.00	83.00	25.00	5.00	0.00	121.00	457.00	51.9
Holy Cross College	4.00	63.00	18.00	3.00	0.00	88.00	332.00	37.7
	12.00	146.00	43.00	8.00	0.00	209.00	789.00	38.3





A Hybrid Cuckoo Approach to Cloud-Based Job Scheduling

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ABSTRACT

Efficient job scheduling in cloud computing environments is crucial to optimize resource allocation, minimize processing time, and enhance system performance. This paper presents a hybrid Cuckoo approach to cloud-based job scheduling, integrating the Cuckoo Search Optimization (CSO) algorithm with other metaheuristic techniques to enhance scheduling efficiency. The hybrid model leverages the global search capabilities of CSO alongside local optimization strategies to improve load balancing and reduce task execution time. The proposed approach dynamically allocates resources based on task requirements and system states, ensuring an optimal balance between computational workloads and available resources. Experimental results, validated on a cloud simulation platform, show significant improvements in job scheduling performance, reducing overall latency and improving throughput when compared to conventional scheduling techniques. This approach holds promise for advancing cloud infrastructure management, offering a scalable and adaptive solution for real-time job scheduling in diverse cloud environments.

Keywords: Technique, computing, CSO, global.

INTRODUCTION

A metaphor, "cloud computing" is similar to the internet. As a service, resources in cloud computing are made available through a network. In Figure 1, you can see that several cloud providers like Google, Amazon, and Yahoo! offer their customers cloud storage, applications, and data. Data can now be accessible from any location at any time



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thanks to the rise of cloud computing. The necessity for a shared physical location has been rendered obsolete by cloud computing. For smaller businesses without the capital to purchase their own storage infrastructure, the cloud is a godsend. Companies can now save money on storage devices by storing all of their data on remote servers in the cloud. Any computer, phone, or tablet with an internet connection can access data stored in the cloud. Through cloud computing, users have access to a plethora of third-party services. Once a user signs up for a cloud service, data is sent between the user and the supplier. Users who use cloud computing can avoid storing data on their personal computers by utilizing a remote virtual platform. There is also the option for customers to host their apps in the cloud, which gives them access to servers where they may process and manipulate data. Cloud computing's tremendous scalability and the convenience of having data accessible from any web browser at any time are driving a lot of interest right now. In general, there are three distinct kinds of cloud computing architectures:

The SaaS model of cloud computing describes the practice of distributing software to end users through subscription. Numerous devices, such as smartphones, tablets, laptops, desktop computers, workstations, and servers, are able to access software stored in the cloud. The platform and infrastructure are completely out of the users' hands. Look at Mail, Google Drive, and Google Talk as examples. The idea of software as a service, sometimes abbreviated as PaaS, is one way to approach cloud computing. The creation and deployment of services can be facilitated by the several programming languages and development environments that service providers offer. Although users may lack control over the underlying infrastructure, they do have the ability to install applications of their own. Google App Engine and Microsoft Azure are two examples. The cloud computing model known as infrastructure as a service, or IaaS, is essentially SaaS. Service providers offer a wide variety of services to their customers, including computing, storage, and networking infrastructure. Users do not have control over storage, deployed apps, operating systems, or anything else related to infrastructure. Rack Space and Amazon Web Services are two instances of cloud services.

Division of Labor

Optimal performance in cloud computing is dependent on well-planned workloads. The purpose of task scheduling is to establish start and end times for various tasks while considering requirements and restrictions. Time and resource constraints both exist. Task scheduling is an essential component of cloud computing. To make the most of available resources and reduce execution time, jobs can be scheduled across many CPUs. The two primary varieties of scheduling are static and dynamic. The scheduling system has been approached from multiple angles. To get the most out of your resources, you need a well-thought-out scheduling approach. The basic procedures for scheduling work are shown in Figure 2. The cloud organizes all of your tasks into queues, each with its own priority. Based on their relative significance, the scheduler assigns tasks to different processors.

Interrelated Duties

In recent times, numerous scheduling methods have emerged to address the issue of cloud computing work scheduling. When it came to task scheduling, I proposed a way to organize various jobs more efficiently. Considering the shortcomings of earlier protocols, this approach organizes tasks that occur on the cloud. The server's throughput, performance, and resource usage are all improved. It solves the issue of task scheduling optimally by using evolutionary algorithms. The Hadoop framework was crucial in completing the mission. A subclass of the scheduler class for work queues is the Genetic Scheduler. This work aims to construct a scheduler for Hadoop that use a genetic algorithm to address the specified issue, thus enhancing Hadoop's capabilities. Introduced the cuckoo search algorithm (CSA), an innovative evolutionary approach to scheduling tasks in remote computing. Not only do cuckoos choose their nests at random, but they also only ever deposit one egg at a time. The host bird's likelihood of finding and identifying an egg of a different species, P_a , might take on values between 0 and 1. A moderate value for P_a greatly improves the algorithm's speed and coverage. In an effort to boost cloud providers' bottom lines, this study introduces a task scheduling strategy based on genetic algorithms.

The GA scheduling function uses the fitness function, which considers user happiness and virtual machine availability, to generate a set of job plans for the population evaluation. In order to find the best time to finish each work, the program repeatedly goes over all populations. A genetic algorithm outperforms other work scheduling



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models, including the ABC-based approach and the round robin model, when it comes to efficiency and effectiveness. A system that prioritizes the satisfaction of its users. Prioritizing jobs according to their distinct attributes, the algorithm employs a sorting approach to distribute them to services that are capable of completing them. Has offered an enhanced cost-based strategy. Optimal utilization of cloud resources is achieved by this program through the use of an efficient allocation technique. More people are able to communicate using computers. When comparing the two algorithms, the higher cost algorithm produces far better results than the ABC algorithm. Minimizing wait times for workload activities is the primary goal of the scheduling technique.

Expected Modeling

In order to maximize resource utilization and decrease runtime and power consumption, we require an immediate scheduling approach. This study is centered around optimal scheduling. The hybrid cuckoo method is used for scheduling in this work. When cuckoo and genetic algorithms are combined, the result is a hybrid algorithm. When compared to both the cuckoo method and the genetic algorithm, the hybrid cuckoo algorithm produces far better outcomes. Visual Studio 2010 used as the simulation tool for this investigation. Visual Studio is used for the development of all jobs using the web. Microsoft Azure is used to set up the cloud infrastructure.

In this article, we'll look closely at these traits:

- schedule
- Assets implementation
- vitality exhaustion

A few things are accomplished by the hybrid cuckoo algorithm:

- Tasks executed in the cloud function without a hitch.
- Efficient use of assets.
- It is less probable that the system will fail.
- The method of dividing up tasks among a large number of CPUs in an efficient manner.
- The goal is to reduce wait times.

System basic architecture

The system's basic architecture is shown in Figure 3. It checks if data about available resources is present before allocating jobs. The system swiftly classifies the tasks according to their workload, and then decides whether they are CPU or memory intensive, provided that the necessary data is available. The next step is to sort the tasks according to the nature of the work. Allotting resources, assigning priorities, and determining when jobs will run are all decisions made by the scheduler. This is not the case while initializing resources. In this step, you'll input a temperature value and then create a virtual machine whose capabilities are dependent on that temperature. A resource database stores the results of data sorting algorithms such as genetic, cuckoo, and hybrid cuckoo. The scheduler takes the needs of the jobs into consideration while distributing resources. Next, you should see if there is any outstanding work that needs doing. Until it stops, it continues to run the burden. The loop is restarted if a task cannot be located.





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A Hybrid Cuckoo's Phraseology

Initialize population of n host nests

Set maximum number of iterations (MaxGen)

Define discovery rate of alien eggs/solutions (pa)

While (t < MaxGen)

Generate new solutions (cuckoos) using Lévy flights

Evaluate the fitness of each cuckoo

Select the best solution among new cuckoos

Compare the new solution with a randomly selected nest (host nest)

If the new solution is better, replace the host nest with the new solution

Abandon a fraction pa of the worst nests and build new ones

Keep the best solutions/nests

Apply additional optimization technique (e.g., genetic algorithm, particle swarm optimization) to improve the solutions

Evaluate the fitness of the new solutions from the hybrid method

Combine the new solutions with the current population

Select the best solutions to form the new population

Update the current generation (t = t + 1)

End While

Return the best solution found

Select the response that has been deemed most suitable.

The hybrid cuckoo algorithm combines the best parts of cuckoo search methods with genetic algorithms, and it achieves amazing results. In optimization, the cuckoo search looks for the best possible value of x to maximize or minimize the function f(x). The cuckoo bird's habit of laying its eggs in the nests of other birds likely played a role in shaping this behavior. Applying ideas from natural selection and evolutionary biology, Genetic Algorithms (GAs) are a type of probabilistic approach. In their quest to find novel answers, genetic algorithms (GA) scour both previously known and uncharted parts of the search space. By combining the strengths of the cuckoo and GA algorithms, we may create a new method that overcomes their respective shortcomings.

CONCLUSIONS AND REVIEW

Here you can see the results of our investigation on the time and resources used by various C# in Visual Studio projects. Windows Azure, a platform as a service (PaaS) from Microsoft, allows users to relocate web-based processes to a local cloud environment. The current state of Visual Studio is depicted in Figure 4, which is a screenshot. You can use cuckoo algorithms, hybrid cuckoo algorithms, or genetic algorithms (GAs) to organize your resources. We may then compare the results of various methods. The capacity of the machine is shown by the view machine. Figure 5 shows the time graph showing the accomplished activities.

Approaches Used

We use the Restrigin Function to check how well this analysis works. The way it is described is as follows:

$$f(x) = A_n + \sum_{l=1}^n [x_l^2 - \text{Acos}(2\pi x_l)]$$





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$$\text{Time} = \frac{\text{Number of instruction jobs } (i)}{\frac{\text{MIPS rating (machine } i)}{\text{Tot temperature}}}$$

$$\text{Energy} = \frac{\text{Tot temperature}}{\text{Avg temperature}}$$

$$* \frac{1}{\text{Tot no of resources used}}$$

Because here,

$$\text{Energ}(\Delta E) \propto \text{Temperature}$$

And $\Delta E \propto \frac{1}{\text{resources}}$

Analysis

These criteria are used to conduct the analysis. It is plausible to conclude from these findings that the suggested research is an improvement above the prior models.

- schedule
- Assets implementation
- vitality exhaustion

As illustrated in Figure 5, the hybrid cuckoo method outperforms the Cuckoo, Genetic, and First Come, First serve (FCFS) algorithms in terms of execution time. So, the hybrid cuckoo algorithm gets the job done quickly and efficiently while still producing top-notch results. The hybrid cuckoo algorithm takes 48.72 seconds to finish 50 jobs, as shown in Table 1. Algorithms such as the cuckoo (61.46 seconds), GA (101.8 seconds), and FCFS(109.18 seconds) require significantly more time. In terms of runtime performance, the hybrid cuckoo algorithm outperforms its predecessors. Compared to cuckoo and GA algorithms, the hybrid cuckoo algorithm is more energy efficient. Table 2 shows that the hybrid cuckoo algorithm improves system performance while drastically reducing energy usage. The numerical data is illustrated visually in Figure 6.

The best use of available resources

In this case, our three integers are -1, 0, and 1. Underutilization of resources is indicated by a score of -1. When it's zero, we're maximizing efficiency; when it's one, we're wasting resources. The resource utilization for 90 jobs is shown in Table 4, while for 50 jobs utilizing the hybrid cuckoo method, it is shown in Table 3. Neither the cuckoo algorithm nor the extended technique are perfect when it comes to resource utilization.

CONCLUSION

“Cloud computing” describes an emerging trend in program and data management that makes use of the internet and a distributed network of computers located in faraway locations. Complexity abounds in the cloud computing challenge of task scheduling. An approach to scheduling that is both simple and effective, the hybrid cuckoo algorithm is known for its reliability and ease of use. This method offers a great plan for scheduling within the framework of Visual Studio. whether it comes to execution time, energy consumption, and optimizing resource use, this method outperforms the GA, FIFO, and cuckoo algorithms, respectively, whether dealing with 50, 90, or 120 jobs. It was determined how well the hybrid cuckoo algorithm performed by comparing its output to that of the GA and cuckoo algorithms. The best algorithm after extensive testing was the hybrid cuckoo approach. We can confirm the results for more than 120 more professions with further study. Various methods of task scheduling can be investigated using the hybrid cuckoo algorithm.

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Table 1 Establishing a Timetable Model

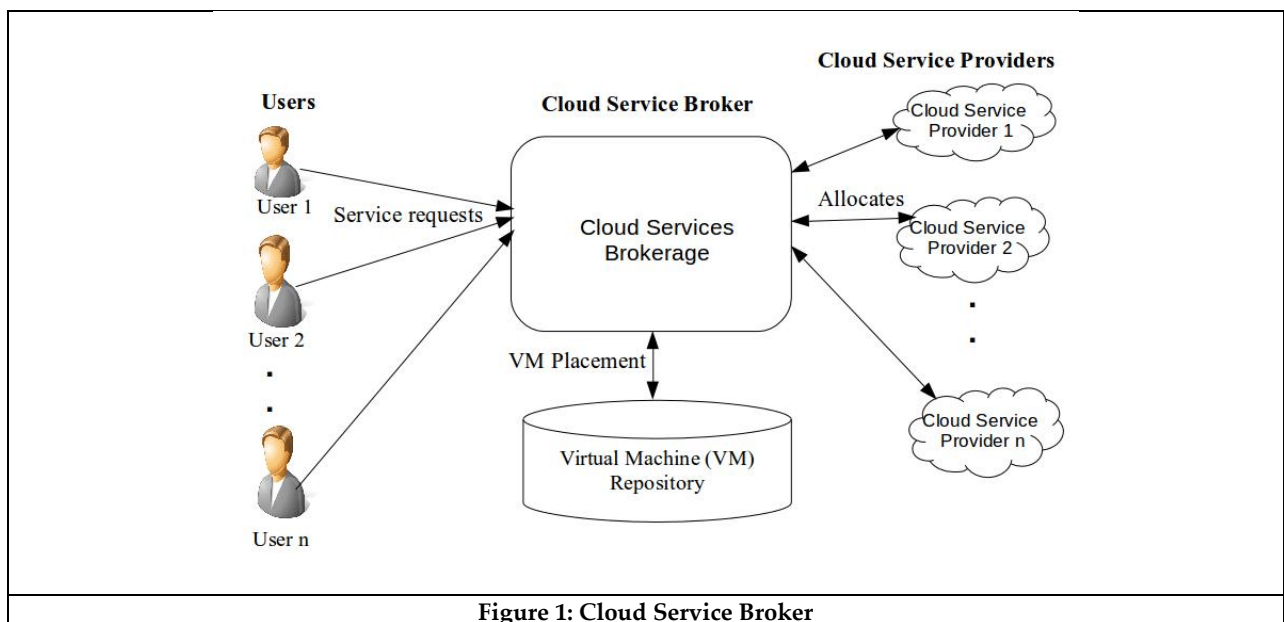
	E-CUCKOO	GA	CUCKOO	FIFO
jobs60	60	90	120	150
jobs90	68	75	96	125
jobs120	72	86	102	138
jobs150	150	200	250	300

Table 2 Table-Based Energy Modeling

	50 enterprises		
	GA	CUCKOO	FIFO
Proper employment	14	23	46
Over employment	25	38	28
Less employment	76	72	68

Table 2 Table-Based Energy Modeling

	90 JOBS		
	GA	CUCKOO	FIFO
Proper employment	24	32	56
Over employment	45	45	63
Less employment	87	69	75





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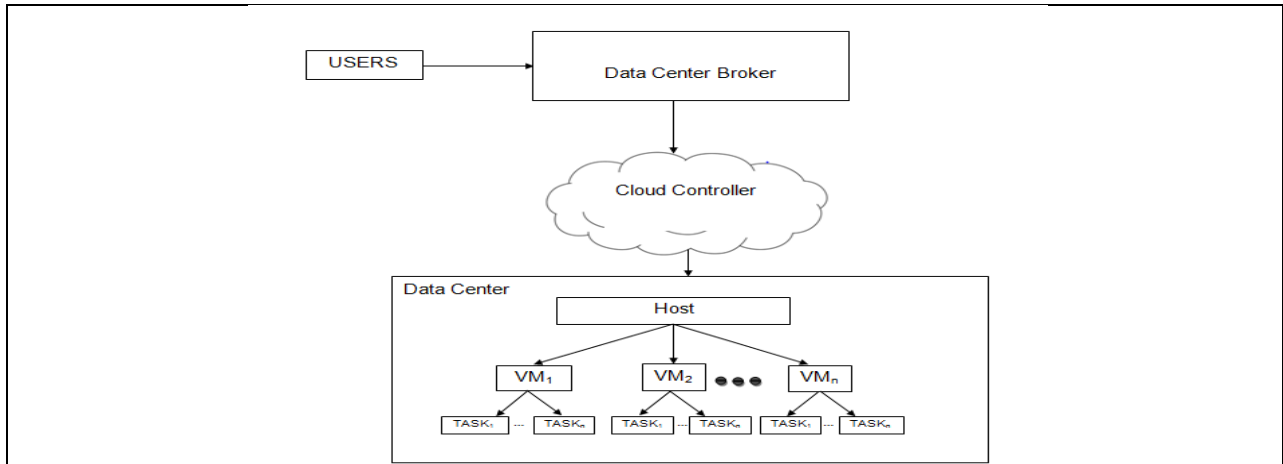


Fig 2: Task scheduling

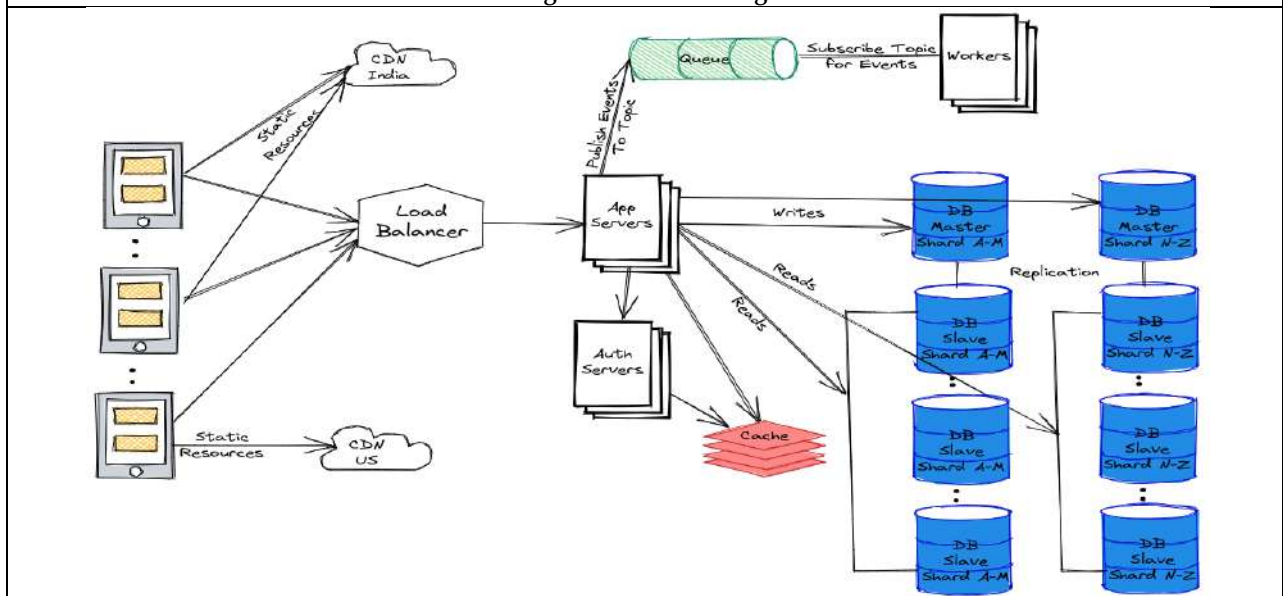


Figure 3: Data base

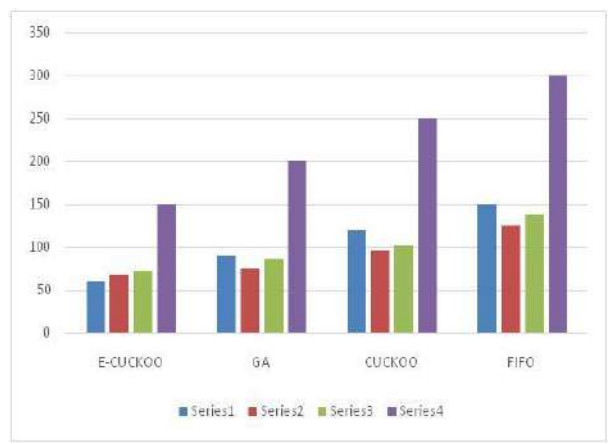


Figure 4 All activities represented by a timetable

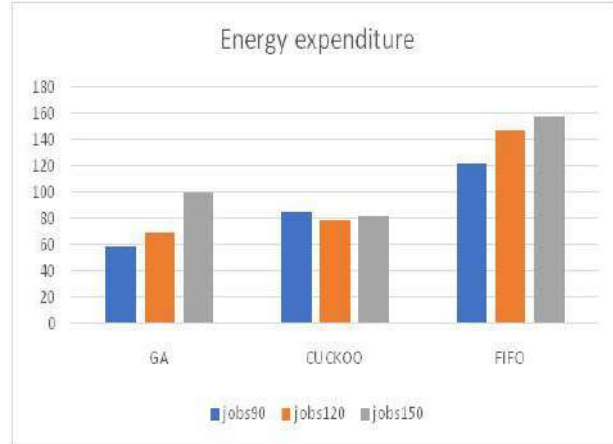


Figure 5: Exerting energy





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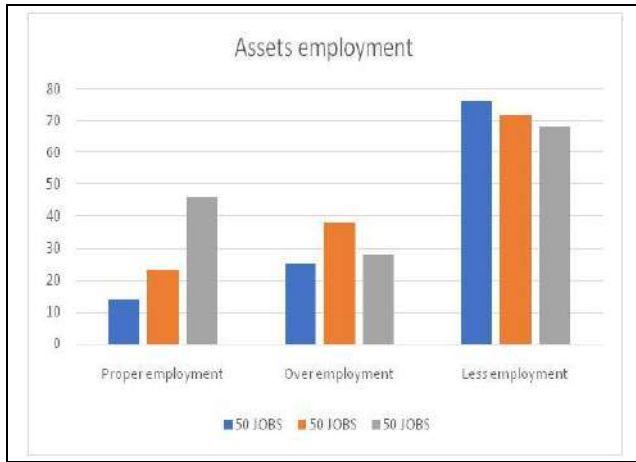


Figure 6: Assets help fifty people get jobs.

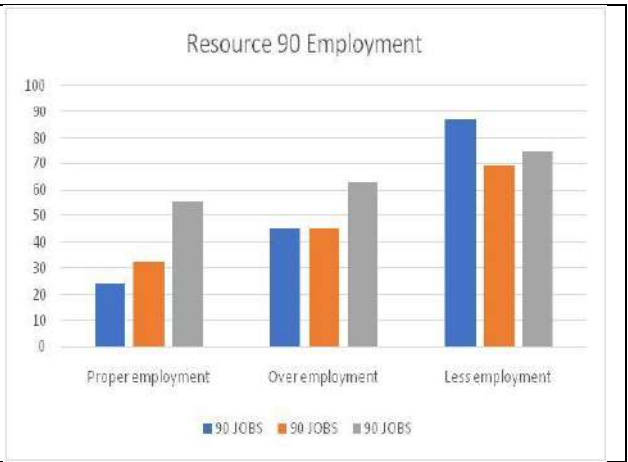


Figure 7: Using assets, ninety people find work





A Comprehensive Review of Machine Learning Techniques for Sentiment Analysis across Various Domains

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ABSTRACT

Sentiment analysis, a crucial aspect of Natural Language Processing (NLP), has gained significant attention in recent years due to its applications in fields such as social media monitoring, customer feedback analysis, and market prediction. This literature review explores the evolution of sentiment analysis through the integration of traditional machine learning algorithms, deep learning models, and advanced NLP techniques. Early approaches relied on manual feature extraction combined with classical machine learning models like Naïve Bayes, Support Vector Machines (SVM), and Random Forests to classify sentiments. However, with the advent of deep learning, architectures such as Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and more recently, transformers like BERT (Bidirectional Encoder Representations from Transformers), have drastically improved sentiment classification accuracy by enabling automatic feature extraction and handling complex linguistic patterns. The review also highlights the growing use of hybrid models that combine NLP techniques with machine learning and deep learning, enhancing the overall performance in sentiment polarity detection, emotion classification, and subjectivity analysis. The review concludes by discussing current challenges in sentiment analysis, such as handling sarcasm, context-aware sentiment interpretation, and multilingual sentiment analysis, while outlining potential directions for future research to further enhance accuracy and scalability.

Keywords: Sentiment Analysis, Natural Language Processing, Machine Learning, Deep Learning, Classification, Pre-Processing





INTRODUCTION

Sentiment analysis, also known as opinion mining, is a critical area of research within Natural Language Processing (NLP) that focuses on identifying and extracting subjective information from textual data [1]. The proliferation of online platforms, such as social media, e-commerce websites, and review forums, has led to an exponential increase in user-generated content, making sentiment analysis essential for understanding public opinion, market trends, and customer feedback. By transforming unstructured text into structured sentiment scores or categories, sentiment analysis provides valuable insights for businesses, governments, and researchers across various domains [2]. Traditional sentiment analysis techniques relied on lexicon-based approaches and manual feature extraction, which were often labor-intensive and lacked the ability to capture the complexities of natural language. Machine learning models such as Naïve Bayes, Support Vector Machines (SVM), and Logistic Regression were then introduced, significantly improving the classification of sentiment by automating feature selection. These models, however, faced limitations in handling large-scale data, contextual understanding, and non-linear linguistic relationships [3] [4].

The emergence of deep learning has revolutionized sentiment analysis by leveraging advanced neural networks that automatically learn features from raw text data. Deep learning architectures, such as Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), including Long Short-Term Memory (LSTM) models, have shown remarkable success in capturing complex patterns in language. Additionally, the introduction of transformers, particularly the BERT (Bidirectional Encoder Representations from Transformers) model, has set new benchmarks for state-of-the-art sentiment analysis, enabling context-aware interpretation and improving the classification of sentiments in nuanced textual inputs [5]. This review aims to explore the application of NLP techniques, machine learning, and deep learning in sentiment analysis, tracing their evolution and highlighting their strengths and limitations. The study also examines hybrid approaches that combine these techniques to achieve higher accuracy in sentiment classification tasks. Additionally, we identify key challenges in sentiment analysis, such as sarcasm detection, multilingual text processing, and context-aware sentiment interpretation, and provide insights into future research directions that could address these issues.

Background Study On Sentiment Analysis

Sentiment analysis, a subset of Natural Language Processing (NLP), focuses on identifying the emotional tone, polarity (positive, negative, neutral), or attitude expressed in a body of text. The origins of sentiment analysis date back to early attempts at extracting subjective information from text through lexicon-based methods and manual rule-based systems. The exponential growth of digital content, particularly in the form of social media posts, reviews, and forums, has made sentiment analysis increasingly important for analyzing public opinion, brand perception, and customer satisfaction across numerous industries.

Early Approaches in Sentiment Analysis

The initial methods for sentiment analysis were primarily lexicon-based, using pre-defined dictionaries of words associated with positive or negative sentiments. These methods classified text by counting sentiment-laden words, which were then aggregated to determine the overall polarity of the text [6]. Though relatively simple, lexicon-based approaches were effective in specific domains where domain-specific dictionaries could be created. However, they struggled with challenges like sarcasm, ambiguity, and context.

Traditional Machine Learning Techniques

To overcome the limitations of lexicon-based approaches, traditional machine learning algorithms were introduced to sentiment analysis. In these approaches, text was first converted into feature vectors using methods such as Bag of Words (BoW) and Term Frequency-Inverse Document Frequency (TF-IDF). These feature vectors were then fed into classifiers like Naïve Bayes, Support Vector Machines (SVM), Random Forest, and Logistic Regression to predict sentiment labels [11].





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Naïve Bayes: One of the earliest machine learning models used for sentiment analysis, Naïve Bayes relies on probabilistic models. It assumes independence among features and performs well in binary classification tasks.

Support Vector Machines (SVM): SVM works by finding the hyperplane that best separates different sentiment classes. It often performs well in high-dimensional feature spaces but can struggle with handling very large datasets efficiently.

Random Forest: As an ensemble method, Random Forest aggregates decisions from multiple decision trees, improving robustness and accuracy in sentiment classification.

These traditional machine learning approaches marked a significant improvement over lexicon-based techniques by automating feature extraction and making the analysis more scalable. However, they still had limitations in capturing the semantic and syntactic nuances of language and often required manual feature engineering[7].

The Rise of Deep Learning in Sentiment Analysis

Deep learning techniques, particularly neural networks, brought about a paradigm shift in sentiment analysis by automatically learning hierarchical features from raw text data. Unlike traditional models, deep learning approaches could capture both shallow and deep semantic structures in language, making them well-suited for sentiment classification.

Convolutional Neural Networks (CNNs): Initially used in image processing, CNNs were later adapted for text classification tasks like sentiment analysis. CNNs use convolutional layers to extract local features from text data and have been effective in identifying sentiment indicators such as key phrases or word patterns.

Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM): RNNs, particularly LSTMs, were developed to handle sequential data and capture dependencies across time steps. LSTMs address the issue of vanishing gradients and are especially useful for processing longer sentences or paragraphs where contextual relationships between words affect sentiment.

Transformers (e.g., BERT): The introduction of transformer architectures, especially BERT (Bidirectional Encoder Representations from Transformers), has set new performance benchmarks in sentiment analysis. BERT captures word relationships bidirectionally, meaning it can consider both the left and right contexts of a word, improving sentiment classification in nuanced or ambiguous text. BERT-based models can also handle complex tasks such as sarcasm detection and emotion classification.

Hybrid Approaches in Sentiment Analysis

Recently, hybrid models that combine traditional machine learning, deep learning, and NLP techniques have emerged to improve the accuracy and robustness of sentiment analysis. These models leverage the strengths of different techniques to address the limitations of individual approaches [8]. For instance, feature selection techniques such as TF-IDF may be used alongside word embeddings like Word2Vec or GloVe, while a deep learning classifier, such as an LSTM, processes the input to predict sentiment.

Background Study On NLP Techniques

Natural Language Processing (NLP) plays a pivotal role in sentiment analysis by enabling computers to understand, interpret, and manipulate human language. Sentiment analysis involves classifying text into predefined sentiment categories, such as positive, negative, or neutral. Over the years, NLP techniques have evolved significantly, ranging from rule-based methods to modern deep learning-based approaches, allowing more accurate sentiment detection in diverse and complex datasets [9] [10].



**Roja and Durairaj****Feature Engineering and Traditional NLP Techniques**

As sentiment analysis grew in complexity, more advanced NLP techniques involving feature engineering and traditional machine learning were introduced. Feature engineering focuses on converting raw text into numerical features that machine learning models can process. Common NLP techniques used for this process include:

Bag of Words (BoW): A popular text representation technique, BoW treats text as a collection of words, disregarding grammar and word order. The frequency of each word in the text is counted, and the text is represented as a feature vector. BoW is effective for basic sentiment classification but ignores semantic relationships between words.

Term Frequency-Inverse Document Frequency (TF-IDF): An improvement over BoW, TF-IDF gives weight to words based on their frequency in a document relative to their occurrence across a larger corpus. Words that appear frequently in a document but less frequently across other documents are given higher weight, helping to identify important sentiment-carrying terms. However, TF-IDF, like BoW, lacks contextual understanding and word order information [11].

N-grams: N-grams capture sequences of N words in the text and are used to incorporate some degree of word order and local context into feature representations. Bigram (2-word) and trigram (3-word) models are commonly used to detect sentiment-related phrases, such as "not bad" or "very good."

Part-of-Speech (POS) Tagging: POS tagging identifies the grammatical role of each word in a sentence (e.g., noun, verb, adjective). In sentiment analysis, POS tagging helps identify sentiment-laden words, especially adjectives and adverbs, which often indicate emotional tone (e.g., "happy," "angry") [13].

Named Entity Recognition (NER): NER identifies and classifies named entities (e.g., people, organizations, locations) in text. While NER is not directly used for sentiment analysis, it can improve performance by identifying contextually important entities, allowing the model to better understand the subject of sentiment.

LITERATURE REVIEW

Naithani, Kanchan, and Yadav Prasad Raiwani [11] This study examined simple situations that make use of important methods and information that can be applied to sentiment analysis. An overview of the work completed up to this point is carried out, noting the findings and conclusions pertaining to different parameters of different researchers who worked on previously known as well as unique and hybrid algorithms using legion techniques. In order to obtain practice percentage and accuracy score in the fields of NLP, sentiment analysis, and text analytics, basic algorithms like Support Vector Machine (SVM), Bayesian Networks (BN), Maximum Entropy (MaxEnt), Conditional Random Fields (CRF), and Artificial Neural Networks (ANN) are also covered. William, P., *et al* [12] explained the initial attempts at sentiment analysis using twitter. The goal of this research is to identify sentiment in tweets based on their subject matter. It makes use of natural language processing techniques to identify the feeling connected to a particular problem. In our study, we classified emotions using three distinct methods: subjectivity-based classification, semantic association-based classification, and polarity-based classification. By determining the grammatical connection between emotion lexicons and the participant, the experiment takes advantage of them. The suggested approach works better than the state-of-the-art text sentiment analysis techniques because of tweets' distinct structure.

Omuya, Erick Odhiambo, George Okeyo, and Michael Kimwele [13] intended to create a sentiment analysis model for social media data that integrates natural language processing with part-of-speech tagging and dimensionality reduction. The model is evaluated against the performance of two different sentiment analysis models utilising the Naïve Bayes, support vector machine, and K-nearest neighbour algorithms. The model uses machine learning approaches to increase sentiment analysis performance, according to experimental results. Balli, Cagla, *et al* [14]



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sought to analyse sentiment using a number of machine learning algorithms using Turkish language datasets gathered from the Twitter platform. In this study, in addition to utilising public datasets for broader generalisation, a new dataset is generated to comprehend the pandemic's effects on individuals and get insights into public sentiment. As a result, a new dataset called SentimentSet was created using Turkish tweets that had been manually categorised as good, negative, or neutral based on the inclusion of terms like "pandemic" and "corona." SentimentSet may also serve as a standard dataset for upcoming studies. Results demonstrate up to around 87% classification accuracy using test data from datasets of both datasets and trained models, and up to approximately 84% using small "Sample Test Data" created using the same techniques as the SentimentSet dataset. These study findings helped to show that sentiment analysis particular to the Turkish language depends on linguistic parameters.

Das, Jay Krishna, Anupam Das, and Joann Rosak-Szyrocka [15] The main objective of this work is to use natural language processing techniques to design a new sentiment analysis model for an e-learning platform. First, benchmark resources are used to collect standard text data on e-learning platforms with user reviews. The collected data is transferred to a pre-processing procedure, which removes superfluous content to optimise sentiment analysis results. Additionally, the glove embedding approach is used to convert words to vectors in order to obtain pertinent data for sentiment analysis. Additionally, Convolutional Neural Networks (CNN) equipped with Gated Recurrent Units (GRU) do sentiment categorisation. Lastly, in the e-learning domain, the feelings are examined using hybrid deep learning. The analysis shows encouraging outcomes for sentiment analysis tasks. Tunca, Sezai, Bulent Sezen, and Violetta Wilk. [16] The purpose of this study was to better comprehend the metaverse concept by revealing the linkages between the metaverse concept and other related concepts, as well as by determining the features of positive and negative attitude. This study employed computational qualitative analysis and artificial intelligence (AI) with natural language processing (NLP) techniques to achieve this goal. The information included metaverse stories from 2021–2022, which were posted on The Guardian website, a significant worldwide mainstream media source. The Natural Language Toolkit (NLTK) from NLP libraries was utilised to determine sentiment, and Leximancer software was utilised to do thematic content analysis of the qualitative data. Additionally, sectoral classifications of the primary themes that surfaced in the Leximancer research were created using an AI-powered Monkeylearn API. Four major themes came out of the Leximancer analysis: "games," "platforms," "Facebook," "metaverse," and "games."

Bari, Anasse, *et al* [17] Artificial intelligence in the form of natural language processing sentiment analysis was used to construct a real-time big data analytics system. Real-time sentiment and content themes, such natural health or personal independence, are ingested, processed, and analysed by the framework. A subsequent dataset assessed the correlation between sentiment scores on Twitter and US immunisation rates. Ruskanda, Fariska Zakhralativa, *et al* [18] suggested a different ansatz for the quantum representation task of sentiment categorisation. In particular, it expands on earlier research in the field of quantum sentiment categorisation by putting forth the Simple Sentiment Analysis (SimpleSA) ansatz, which is a substitute for the Instantaneous Quantum Polytime ansatz. The SimpleSA ansatz's choice to disregard noun parameterisation is a fundamental component. In terms of the amount of parameters and gates, the suggested SimpleSA is less complex than the other ansätze. Furthermore, the H-CNOT-Rz-H compound block construction used in the SimpleSA ansatz works better than the Instantaneous Quantum Polytime (IQP) ansatz at 85.00% accuracy, according to experimental results. In addition, SimpleSA optimisation converges 20.89% faster for the Simultaneous Perturbation Stochastic Approximation (SPSA) approach with 130 iterations than Instantaneous Quantum Polytime (IQP). Applications of quantum computers for sentiment analysis and classification can benefit from the suggested study.

Sadanand, Vijaya Shetty, *et al*. [19] Proposing and training an LSTM model with a dataset of hand graded essays with scores is one of the research's primary goals. Sentiment analysis is used to identify whether the essay's sentiment is neutral, positive, or negative. A sentiment classifier that evaluates sentiment according to students' approaches to a topic is built using the Twitter sample dataset. Every essay is also examined for grammatical mistakes and plagiarism in order to determine how original it is. Ounacer, Soumaya, *et al*. [20] recommended extracting reviews from travel websites like Booking and TripAdvisor and using the Aspect-Based Sentiment Analysis method to them. This method is based on two primary steps: each aspect's sentiment classification and aspect extraction. A topic modeling-



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based method is suggested for aspect extraction that makes use of the semi-supervised CorEx (Correlation Explanation) technique for classifying word sequences into entities. Regarding sentiment classification, a variety of supervised machine learning methods are applied to link a given aspect expression to a sentiment (positive, negative, or neutral). Opinion corpus experiments have produced very positive results.

Hasan, Mahmud, *et al.* [21] Submitted a dataset with annotations in Bangla for sentiment analysis on the recent conflict between Russia and Ukraine. The dataset was created by gathering comments in Bangla from a variety of videos that three well-known Bangladeshi YouTube TV news channels posted while reporting on the ongoing crisis. 10,861 Bangla comments in total were gathered and classified into three polarity sentiments: neutral, pro-Russia (negative), and pro-Ukraine (positive). By testing with various transformer-based language models that had all been pre-trained on an unlabelled Bangla corpus, a benchmark classifier was created. The dataset we acquired was used to refine the models. All five transformer language models—BanglaBERT, XLM-RoBERTa-base, XLM-RoBERTa-large, Distil-mBERT, and mBERT—were subjected to hyperparameter optimisation. Several assessment criteria, such as the F1 score, accuracy, and AIC (Akaike Information Criterion), were used to assess and analyse each model. With an F1 score of 0.82, the top-performing model obtained the highest accuracy of 86%. BanglaBERT surpasses the baseline and all other transformer-based classifiers in terms of accuracy, F1 score, and AIC.

Gunasekaran, Karthick Prasad [22] discussed the opportunities and difficulties in SA, including how to handle irony and sarcasm, analyse data that is multilingual, and address ethical issues. Twitter was selected as one of the biggest online social media networks to offer a real-world case study. The researchers also clarified the various fields in which SA is applied, such as social media, healthcare, marketing, banking, and politics. Additionally, a thorough and comparative study of current methodologies, datasets, and evaluation criteria is included in the paper. The final objective is to provide academics and practitioners with a thorough analysis of SA approaches, point out any gaps in the field, and make recommendations for potential enhancements. The goal of this research is to improve the accuracy and efficiency of SA procedures, producing results that are more error-free and seamless. Mishra, Shreyash, *et al.* [23] Sentiment analysis and opinion mining is a field of study that looks into people's attitudes, judgements, sentiments, and opinions in order to derive meaning from their written words. One of the most active research areas in text, online, and data mining is natural language processing. Sentiment analysis has several applications, including measuring public opinion on goods and services and evaluating the effects of events on social networks. Sentiment analysis is becoming more and more significant, much as blogs, forums, microblogs, and social networks like Facebook and Twitter have increased in popularity. Digitally recorded sentiments can be quantified by lexical-based methods and supervised machine learning.

Khaiser, Fareed Kaleem, Amna Saad, and Cordelia Mason [24] In this study, student opinions regarding institutional facilities are gathered by sentiment analysis, often known as opinion mining or emotional artificial intelligence (AI). An online text must first be analysed to determine whether it has a positive, negative, or neutral emotional tone. Sentiment analysis is a subfield of natural language processing (NLP), which can be utilised with machine learning techniques to extract and classify data. Since students are customers in an educational context, it is crucial to find out if they are happy with the facilities or services offered. This study examined how college students felt about the books, audio CDs, and video CDs; the services that the library personnel offered; and the personal computers that are available to them as part of the library's amenities. Surveys were used in the current study to collect data and evaluate the degree to which students' requirements are met. Shinde, Varun [25] This covers issues like languages and missing data in addition to solutions like multilingual models and transfer learning. Additionally covered are developments in multilingual perceptual analysis models for natural language processing. The techniques employed were gathering multilingual Twitter data, using that data to pre-train language models, generating sentiment analysis data sets for every language, and fine-tuning the developed models in comparison to the originals.

Gupta, Shelley, Archana Singh, and Vivek Kumar [26] 1,68,548 tweets expressing the opinions of 650 well-known people have been downloaded from all around the world. The findings demonstrate how the suggested framework for natural language processing demonstrates that the presence of emojis in sentiments frequently appears to alter



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the sentiment's overall polarity. By extension, a dictionary of sentiments is used to assess the polarity of text, and the CLDR name of the emoji is used to assess the correct polarity of emoji patterns. Finally, the suggested distinguishing language features are assessed based on the performances of three machine learning classifiers: SVM, DT, and Naïve Bayes. The reliable tests show that when compared to other ML classifiers, the suggested method performs better than the SVM classifier. The suggested polarity detection generator outperformed current state-of-the-art methods in achieving an outstanding view of the sentiments expressed in the sentence by utilising the concept flow established based on linguistic features, polarity inversion, coordination, and discourse patterns. Li, Yan [27] created a text sentiment analysis model and a picture-text multimodal sentiment analysis model in social networks, respectively, after studying the sentiment analysis algorithms in social networks at two levels: unimodal and multimodal. The efficiency of the two models was confirmed by comparing the experiments with the current models on a number of datasets. The accuracy of the two models outperformed the benchmark models by 4.45% and 5.2%, respectively. By practically applying the optimised convolutional neural network recurrent optimisation network to single task and multitask and comparing it with other deep learning classifiers currently in use, the viability of applying the network to social network sentiment analysis is confirmed.

Kasula, Balam Yadav [28] explored the field of sentiment analysis using a variety of approaches and strategies derived from machine learning and natural language processing. The search for the best accurate model is still ongoing, despite earlier efforts examining binary (positive or negative), ternary (containing neutral), or even more complicated sentiment classifications (such as joyful, sad, afraid, astonished, or wrathful). As a result, this study looks into using sentiment analysis to analyse comments on YouTube videos, concentrating on polarity identification. Researchers studying data mining and sentiment analysis can benefit greatly from the research's clarification and classification of these methodologies. Thimmapuram, Madhuri, Devasish Pal, and Gouse Baig Mohammad [29] Analysing polarity in noisy Twitter feeds is the primary objective. This study details the idea behind a data analysis that pulls out a large number of tweets. Results employ tweets to categorise people' perceptions into positive and negative groups. By inputting a keyword, the user can discover its nature based on the most recent tweets that contain the inputted keyword. Every tweet is categorised based on whether it makes you feel good or unhappy. Information about movie reviews is gathered from the IMDB website. Naive Bayes, a machine learning algorithm, was applied. The outcome of this model was tested using several test methodologies. Furthermore, our algorithm performs quite well when mining sentences that are directly extracted from Twitter. The accuracy was 92.50%, and the execution speed and generalisation were also strong points. Sv, Praveen, *et al.* [30] In this study, sentiment analysis and topic modeling—two methods often used in natural language processing—were used to examine Indian perspectives on COVID-19 booster dosage vaccinations. For this study, we examined tweets written by Indian nationals. The Indian government expedited the COVID-19 booster dose immunisation protocol in late July 2022. The government, health policy officials, and policymakers will be able to implement the health policy more effectively and achieve the desired outcomes if they have a thorough understanding of the feelings and worries that the public has regarding it.

Research Gap

Despite the significant advances in sentiment analysis, there remain several challenges:

Sarcasm and Irony: Detecting sarcasm and irony is one of the most challenging aspects of sentiment analysis. The literal meaning of words in sarcastic statements often contradicts their intended sentiment, making it difficult for models to correctly classify such text.

Context-Awareness: Traditional sentiment analysis methods often fail to capture the context in which a sentiment is expressed, leading to inaccurate classifications. Context-aware models, such as transformers, aim to address this issue.



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Multilingual Sentiment Analysis: Analyzing sentiment across multiple languages presents challenges due to differences in grammar, syntax, and cultural nuances. Pretrained multilingual models like mBERT have been developed to address this, but they still require further refinement.

Future Research Direction

The future of sentiment analysis lies in further advancements in deep learning, transfer learning, and hybrid models. Researchers are increasingly focusing on building more context-aware models, improving the handling of sarcasm and irony, and creating robust multilingual sentiment analysis systems. Moreover, the integration of sentiment analysis with other AI techniques, such as emotion recognition and cognitive computing, promises to expand its applications in fields like healthcare, finance, and social media analysis. This background study provides a comprehensive understanding of the development of sentiment analysis techniques, highlighting the transition from traditional lexicon-based methods to sophisticated deep learning approaches. The continuous improvement of NLP, machine learning, and deep learning techniques has made sentiment analysis an indispensable tool for extracting meaningful insights from large-scale text data.

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A Literature Review of the Dimensionality Reduction Techniques for the Healthcare Domain

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ABSTRACT

The rapid advancement of healthcare technology has led to an explosion of multi-modal data, including electronic health records, medical imaging, genomics, and wearable device outputs. This diverse data landscape poses significant challenges in terms of dimensionality reduction, which is essential for effective analysis and interpretation. This literature review explores various multi-modal data fusion techniques aimed at enhancing dimensionality reduction in healthcare analytics. We categorize the existing approaches into three main frameworks: feature-level fusion, decision-level fusion, and hybrid methods, each exhibiting unique strengths and limitations. The review critically evaluates recent studies that leverage machine learning algorithms, deep learning architectures, and statistical methods for integrating multi-modal data. By synthesizing findings from various domains, we highlight the impact of dimensionality reduction on predictive modeling, disease diagnosis, and personalized treatment strategies. Furthermore, we discuss the challenges and future directions in the field, emphasizing the need for robust methodologies that ensure data integrity and interpretability while maintaining patient privacy. This review aims to provide a comprehensive understanding of current trends and advancements in multi-modal data fusion techniques, offering insights for researchers and practitioners in the realm of healthcare analytics.

Keywords: Healthcare Analytics, Dimensionality Reduction, Data Fusion Technique





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INTRODUCTION

In recent years, the healthcare sector has experienced a profound transformation driven by technological advancements and the proliferation of data [1] [2]. The integration of diverse data sources—ranging from electronic health records (EHRs) and medical imaging to genomic sequences and data from wearable devices—has created a multi-modal data landscape. Each of these modalities provides unique insights into patient health, but they also introduce significant complexity due to their inherent heterogeneity in format, structure, and information content. Multi-modal data fusion refers to the process of integrating data from multiple sources to achieve a more comprehensive understanding of a given phenomenon. In the context of healthcare analytics, effective data fusion is crucial for enhancing clinical decision-making, improving patient outcomes, and advancing personalized medicine. However, the diverse nature of these data sources often results in high dimensionality, making it challenging to extract meaningful patterns and insights. High-dimensional datasets can lead to issues such as the "curse of dimensionality," where the volume of the feature space increases exponentially, potentially diminishing the performance of machine learning algorithms and complicating the interpretability of models.

Dimensionality reduction techniques play a pivotal role in addressing these challenges by reducing the number of features while preserving the essential information required for analysis. By minimizing dimensionality, these techniques can improve computational efficiency, reduce storage costs, and enhance model performance. Moreover, effective dimensionality reduction can mitigate overfitting, improve generalization, and facilitate the visualization of complex data structures. Various methodologies have been proposed to achieve dimensionality reduction in the context of multi-modal data fusion. These can broadly be categorized into feature-level fusion, where data from different modalities is combined at the feature level before analysis, and decision-level fusion, where models built on individual modalities are combined to form a consensus decision. Hybrid approaches that integrate both feature-level and decision-level fusion techniques have also gained traction, promising to leverage the strengths of each method [3] [4].

Despite the significant progress in multi-modal data fusion techniques, several challenges remain. Issues such as data inconsistency, missing values, and the need for effective alignment of disparate data sources complicate the fusion process. Additionally, the selection of appropriate dimensionality reduction techniques that suit the specific characteristics of each data modality is critical for achieving optimal results [5] [6]. This literature review aims to synthesize the current state of research on multi-modal data fusion techniques for enhanced dimensionality reduction in healthcare analytics. By critically examining the existing methodologies, we will identify trends, challenges, and opportunities in this evolving field. Our review will provide insights into how these techniques can be effectively applied to improve predictive modeling, disease diagnosis, and personalized treatment strategies, ultimately contributing to the advancement of healthcare analytics. The findings of this review will serve as a valuable resource for researchers and practitioners seeking to harness the potential of multi-modal data in healthcare.

Background Study on Healthcare Analytics

Healthcare analytics is the systematic analysis of healthcare data to derive actionable insights that enhance decision-making, improve patient outcomes, and optimize operational efficiency. The integration of data science techniques and healthcare information systems has paved the way for the emergence of analytics as a vital tool in the healthcare sector. It encompasses a wide range of methodologies, including descriptive, predictive, and prescriptive analytics, each serving distinct purposes in analyzing healthcare data [7] [8].

Descriptive Analytics provides insights into historical data, allowing stakeholders to understand trends, patterns, and correlations within healthcare datasets. It typically involves the use of data visualization tools to present findings in an understandable format.



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Predictive Analytics utilizes statistical algorithms and machine learning techniques to forecast future events based on historical data. In healthcare, predictive models are employed for various applications, such as predicting disease outbreaks, patient readmissions, and treatment outcomes.

Prescriptive Analytics goes a step further by recommending actions based on predictive insights. This form of analytics helps healthcare providers optimize resource allocation, enhance treatment plans, and improve patient care protocols. The effectiveness of healthcare analytics is heavily dependent on the quality and variety of data available. Data sources in healthcare are diverse, encompassing:

Electronic Health Records (EHRs): Digital versions of patients' paper charts, EHRs contain a wealth of information, including patient demographics, medical history, medications, treatment plans, and laboratory results.

Medical Imaging: Imaging modalities such as X-rays, MRIs, and CT scans generate complex data that require advanced analytics for interpretation. Techniques such as image recognition and analysis have emerged to extract valuable information from medical images.

Genomic Data: The advent of genomics has provided insights into individual genetic makeups, paving the way for personalized medicine. Analyzing genomic data enables healthcare providers to tailor treatments based on genetic predispositions.

Wearable Devices: Devices such as smartwatches and fitness trackers collect real-time health data, including heart rate, physical activity, and sleep patterns. This data is increasingly used to monitor chronic conditions and promote preventive care. The landscape of healthcare analytics has evolved significantly over the past few decades:

Early Days: Initially, healthcare analytics focused primarily on descriptive statistics to report on patient outcomes and operational efficiency. Data was often siloed, with limited integration across departments.

Emergence of Predictive Analytics: With the advent of advanced statistical methods and machine learning algorithms, predictive analytics gained traction in the late 2000s. Healthcare organizations began employing predictive models to forecast patient needs and identify high-risk patients.

Current Trends: Today, the integration of artificial intelligence (AI) and machine learning in healthcare analytics has revolutionized the field. AI-driven tools can analyze complex datasets, identify patterns, and provide real-time insights, leading to improved clinical decision-making and personalized treatment approaches.

Background Study on Dimensionality Reduction Techniques

Dimensionality reduction refers to a set of techniques aimed at reducing the number of input variables or features in a dataset while retaining its essential information. In the context of healthcare analytics, the explosion of data from diverse sources—such as electronic health records, medical imaging, genomic studies, and wearable devices—has resulted in high-dimensional datasets. While this wealth of data can provide rich insights into patient health and treatment outcomes, high dimensionality often leads to challenges such as overfitting, increased computational costs, and difficulties in visualization and interpretation. Dimensionality reduction techniques serve to simplify these complex datasets by extracting relevant features and eliminating redundant or irrelevant information. This simplification not only enhances the performance of machine learning algorithms but also aids healthcare practitioners in making more informed decisions based on the underlying patterns present in the data. Dimensionality reduction techniques can be broadly categorized into two main types: feature selection methods and feature extraction methods.



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Feature Selection: This approach involves selecting a subset of the most relevant features from the original dataset [9][10]. It is particularly useful when the original features contain irrelevant or redundant information that can obscure meaningful patterns. Common feature selection techniques include:

Filter Methods: These methods evaluate the relevance of features based on their statistical properties, independent of the machine learning algorithm used. Examples include chi-square tests, correlation coefficients, and mutual information.

Wrapper Methods: These techniques use a predictive model to evaluate the performance of feature subsets. They iteratively select features based on model accuracy, often employing techniques like recursive feature elimination.

Embedded Methods: These approaches perform feature selection during the model training process, integrating the selection with the learning algorithm. Examples include Lasso regression and decision tree-based methods like Random Forest.

Feature Extraction: This approach transforms the original features into a new feature space with reduced dimensionality. Feature extraction techniques create composite features that capture the underlying structure of the data. Common feature extraction methods include:

Principal Component Analysis (PCA): A linear transformation technique that reduces dimensionality by projecting the data onto a lower-dimensional space while maximizing variance.

t-distributed Stochastic Neighbor Embedding (t-SNE): A nonlinear technique particularly suited for visualizing high-dimensional data in a lower-dimensional space. It emphasizes preserving local structures in the data.

Linear Discriminant Analysis (LDA): A supervised method that seeks to find the linear combinations of features that best separate different classes in the dataset.

Autoencoders: A type of neural network used for unsupervised feature extraction, where the model learns to encode the input data into a lower-dimensional representation and then reconstruct it. \ The application of dimensionality reduction techniques in healthcare is vast and varied, with implications across several areas:

Disease Diagnosis and Prediction: Dimensionality reduction techniques are often employed to enhance the performance of predictive models in disease diagnosis. By reducing the number of features, these techniques help mitigate overfitting and improve model interpretability, which is crucial in clinical settings. For example, PCA has been used to analyze genomic data for predicting cancer outcomes, while LDA has been applied to differentiate between various types of diseases based on clinical parameters.

Medical Imaging: In medical imaging, dimensionality reduction techniques are used to extract relevant features from high-dimensional image data, facilitating the identification of patterns indicative of specific conditions. For instance, PCA and autoencoders have been utilized to enhance image quality and reduce noise in MRI and CT scans.

Personalized Medicine: The integration of multi-modal data, including genomic, clinical, and lifestyle data, is essential for advancing personalized medicine. Dimensionality reduction techniques enable the identification of significant biomarkers that can inform tailored treatment plans, enhancing the efficacy of interventions.

Patient Monitoring and Wearable Devices: Data collected from wearable devices, which often include numerous features related to physical activity, heart rate, and sleep patterns, can be analyzed using dimensionality reduction techniques. This analysis helps in identifying trends and anomalies in patient health, facilitating timely interventions.





LITERATURE REVIEW

Rani, Ridhima, *et al* [11] In the era of big data, diverse data types characterised by extensive samples and high dimensionality are proving essential across various domains, including data mining, pattern recognition, machine learning, and the Internet of Things (IoT), among others. The intricacy of data processing escalates with the augmentation of the dataset's size. The term "complexity" denotes the challenge of identifying and utilising correlations among many elements of a dataset. Consequently, employing a dimensionality reduction (DR) method can eliminate the complexity among various features. This article examines the literature on data recovery approaches in the context of enhancing storage and processing of large data across various IoT applications, highlighting its advantages, characteristics, classification, and evaluation criteria. Moreover, the essay delineates prospective research issues and provides insights into the applications of data reduction (DR) across several areas, thereby informing readers about the relevance of a specific data reduction technique. Rashid, Lubaba, *et al* [12] intended to ascertain the impact of dimensionality reduction on IoT data on storage and communication expenses. It also examines the impact of dimensionality reduction of IoT data on the efficacy of various classification algorithms applied to it. Dimension reduction has been shown to decrease the storage and communication expenses of IoT data, albeit at the expense of the performance of classification algorithms applied to the reduced-dimensional data. Nonetheless, this decline in performance is insignificant relative to the optimisation of storage and transmission costs.

Ashraf, Mohsena, *et al* [13] Contemporary data analysis entails managing extensive datasets, including time-series data. This data is distinguished by its high dimensionality, substantial volume, and the existence of noise and redundant features. Nevertheless, the "curse of dimensionality" frequently presents challenges for learning methodologies, which may struggle to recognise the temporal correlations inherent in time-series data. To resolve this issue, it is imperative to diminish dimensionality while maintaining the inherent characteristics of temporal dependencies. This will mitigate diminished learning and prediction performance. This paper introduces twelve distinct dimensionality reduction techniques tailored for time-series data, categorised by supervision, linearity, time and memory complexity, hyper-parameters, and limitations. Vinutha, M. R., *et al* [14] An Enhanced Principal Component Analysis (EPCA) is proposed, which minimises the dimensions of the medical dataset while meticulously preserving critical information, thereby attaining superior outcomes. The notable dimensionality reduction approaches, including Principal Component Analysis (PCA), Singular Value Decomposition (SVD), Partial Least Squares (PLS), Random Forest, Logistic Regression, Decision Tree, and the proposed EPCA, are examined in relation to the following Machine Learning (ML) algorithms: Support Vector Machine (SVM), Artificial Neural Networks (ANN), Naïve Bayes (NB), and Ensemble ANN (EANN) evaluated by statistical metrics including F1 score, precision, accuracy, and recall. EPCA directly transferred the data to a lower-dimensional space to enhance the distribution of the data in that form.

Henouda, Salah Eddine, *et al* [15] This study aims to examine the impact of dimensionality reduction methods (DRTs) on the classification of breast cancer (BC). We concentrated on the following five dimensionality reduction techniques (DRTs): Auto-Encoders (AE), T-Distributed Stochastic Neighbour Embedding (T-SNE), Recursive Feature Elimination (RFE), Isometric Feature Mapping (Isomap), and Principal Component Analysis (PCA). These methods are integrated with two renowned classifiers: Support Vector Machine (SVM) and Multilayer Perceptron (MLP). They are utilised for BC categorisation. The Breast Cancer Wisconsin Diagnostic (WDBC) dataset was utilised to validate the experiments conducted in this study. The former was supplied by the machine learning repository of the University of California, Irvine (UCI). Ahmad, Noor, and Ali Bou Nassif [16] Dimensionality reduction strategies are essential for the analysis and interpretation of high-dimensional data. These strategies collect various data attributes of significance, including dynamic structure, input-output linkages, inter-data set correlation, covariance, and others. Dimensionality reduction involves transforming a collection of high-dimensional data features into a lower-dimensional representation. This study addresses the inadequate performance of learning models caused by high-dimensional data by examining five distinct dimensionality reduction techniques. A comprehensive comparison is



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made between reduced dimensionality data and the original dataset utilising statistical and machine learning algorithms.

Rafieian, Bardia, Pedro Hermosilla, and Pere-Pau Vázquez [17] presented a straightforward yet potent transformation for vector datasets that alters their values according to weight frequencies. This strategy greatly enhances the efficacy of dimensionality reduction algorithms in many contexts. We analyse a selection of renowned labelled datasets to illustrate the effectiveness of our methods. The results indicate enhanced clustering efficacy in classifying data within the limited space. The idea offers a thorough and flexible strategy to improve the results of dimensionality reduction for visual data analysis. Ali, Mehak, *et al* [18] This paper combines Principal Component Analysis (PCA) with eigenvector integration techniques to present a new approach for dimensionality reduction in time-domain optimisation. Effective dimensionality reduction is increasingly obstructed by data complexity, which is crucial for enhancing computational efficiency and improving model performance. Principal Component Analysis (PCA) is a crucial instrument in machine learning and data processing, particularly advantageous for high-resolution data. This study examines the influence of Principal Component Analysis (PCA) on the efficacy and precision of three classification algorithms: Support Vector Machine (SVM), Random Forest (RF), and Convolutional Neural Network (CNN) in the context of medical image categorisation. Data photos of melanoma and eczema were utilised, with Visual Geometry Group 16 (VGG16) employed for feature extraction, followed by Principal Component Analysis (PCA) for dimensionality reduction. The findings indicate that Principal Component Analysis (PCA) enhances processing speed without significantly impacting accuracy or other performance metrics.

Mwanga, Emmanuel P., *et al* [19] Fourier transform infrared spectrometers, categorised into two distinct age classes. The dimensionality of the spectral data was diminished by unsupervised principal component analysis or t-distributed stochastic neighbour embedding, subsequently employed to train deep learning and conventional machine learning classifiers. The efficacy of transfer learning was assessed to enhance the transferability of models in predicting mosquito age classes from novel populations. Kabir, Md Faisal, Tianjie Chen, and Simone A. Ludwig [20] Examined the effects of various dimensionality reduction strategies on machine learning models employed for cancer prediction. Dimensionality reduction methods, including principal component analysis (PCA), kernel PCA, and autoencoders, were employed to diminish the dimensionality of the RNA sequencing data. Two machine learning classifiers, specifically a neural network and a support vector machine, were trained and evaluated utilising the original, dimensionally reduced, and cancer-relevant datasets. Multiple metrics, including accuracy, precision, recall, F-measure, receiver operating characteristic curve, and area under the curve, were employed to evaluate classifier performance.

Bharadiya, Jasmin Praful [21] Anomaly detection has emerged as an essential technology across various application domains, particularly in network security. This document outlines the categorisation difficulty of anomaly detection utilising machine learning algorithms on network data. The KDD99 dataset is utilised to explore and evaluate dimensionality reduction and classification algorithms for network intrusion detection systems (IDS). Principal Component Analysis for dimensionality reduction and Support Vector Machine for classification have been utilised in the application of network data, and the outcomes have been analysed. The results indicate a reduction in execution time for classification when the dimensionality of the input data is diminished. Additionally, the precision and recall metrics of the classification algorithm demonstrate that the SVM with PCA technique exhibits greater accuracy, evidenced by a decrease in misclassifications. The vast data in health research is highly intriguing, as data-driven studies can progress more rapidly than hypothesis-driven research, despite the increasing prevalence of large databases, which complicates interpretation. Principal Component Analysis (PCA) can be employed to reduce the dimensionality of certain datasets. improves interpretability while preserving the majority of the information. It accomplishes this by introducing novel variables that are independent of each other. Saheed, Yakub Kayode [22] Intended to offer machine learning-based methodologies for the classification of acute myeloid leukaemia and acute lymphoblastic leukaemia utilising microarray gene expression patterns. We utilised logistic regression, very randomised trees classifier, ridge classifier, AdaBoost classifier, linear discriminant analysis, random forest, gradient boosting, and k-nearest neighbours classifier. Principal component analysis was employed for dimensionality



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reduction. We utilise two separate cross-validation methods in this work as they yield more precise skill evaluations than prior approaches. Six unique performance metrics for categorisation were employed to assess these methodologies.

Pandey, Rajiv, *et al* [23] offered an investigation employing Principal Component investigation (PCA), a prevalent dimensionality reduction technique, to address the dimensionality issue of data. We evaluate the importance of employing PCA to diminish the dimensions of the dataset utilised in an IoMT-enabled system, integrating our research with a previously established framework titled "Prenatal Healthcare System of Remote Mother and Foetal Surveillance via IoMT." The prenatal device enhances the probability of a safe and healthy delivery while mitigating pregnancy hazards. The survival of a foetus relies on regular health evaluations, which are both beneficial and crucial. The information utilised in the experiments comprises essential prenatal device parameters for a foetus, potentially assisting medical professionals with real-time health updates. We employ PCA to emphasise variance and reveal major patterns in the dataset to reliably predict outcomes. Saidulu, D., and R. Sasikala [24] developed a computationally efficient approach for dimensionality reduction and categorisation of healthcare-related data. The developed framework is capable of handling data with both discrete and continuous properties. The experimental assessment is conducted on the Parkinson's disease categorisation database (Sakar *et al.*, 2018). The statistical performance metrics employed include validation and test accuracy, precision, recall, F1-score, among others. The decreased dimensional data will confer computational complexity advantages when processed for modelling and constructing prediction systems. To demonstrate the optimality of the proposed framework, a comparative analysis is conducted with notable existing techniques.

Hussein, Safa Saad, *et al* [25] This work examined the efficacy of data dimensionality reduction approaches and machine learning algorithms in enhancing the detection accuracy of cardiac anomalies in WBAN sensors. Dimensionality reduction was executed utilising principal component analysis (PCA), independent component analysis (ICA), and spatial correlation techniques. Decision Tree and Multilayer Perceptron algorithms were employed for arrhythmia prediction, and their performances were compared. Numerical simulations and Python code analysis shown that the implementation of data reduction strategies markedly enhanced the reliability and efficacy of WBAN sensors in managing extensive datasets. Moreover, the implementation of PCA, ICA, and spatial correlation techniques significantly diminished the battery energy consumption of WBAN sensors, as well as the requirements for data storage, computational complexity, and processing duration. These realistic methods may enable healthcare practitioners to react proactively before patients face life-threatening diseases. Karthikeyani, S., S. Sasipriya, and M. Ramkumar [26] This study examined the amalgamation of dimensionality reduction techniques with diverse deep learning classifiers to enhance the precision and efficacy of cardiac illness classification. Uniform Manifold Approximation and Projection, in conjunction with Principal Component Analysis, is employed for dimensionality reduction, effectively capturing both global and local data structures. Classification is performed using deep learning classifiers, including convolutional neural networks, capsule networks, recurrent neural networks, graph neural networks, deep long short-term memory networks, and attention-based convolutional neural networks. The Adaptive Spiral Flying Sparrow Search algorithm optimises classifier parameters to boost accuracy. Performance is assessed using multiple criteria, including the area under the receiver operating characteristic curve, accuracy, F1-Score, precision, and recall.

Kherwa, Pooja, *et al* [27] Conducted an extensive literature review to furnish a comprehensive application-oriented understanding of diverse dimensionality reduction strategies, serving as a reference for selecting the appropriate dimensionality reduction approach to enhance performance across distinct applications. The authors conducted comprehensive tests on two distinct datasets to compare the efficacy of several linear and non-linear dimensionality reduction strategies. PCA, a linear dimensionality reduction method, surpassed all other strategies included in the studies. Indeed, nearly all linear dimensionality reduction methods far surpassed the non-linear strategies on both datasets, exhibiting a substantial margin of error. Dessureault, Jean-Sébastien, and Daniel Massicotte [28] provided a novel approach for selecting the optimal dimensionality reduction technique inside a supervised learning framework. It is also beneficial to eliminate or reconstruct features until the desired resolution is attained. The target





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resolution may be user-defined or automatically determined by the algorithm. The method employs regression or classification, assesses the outcomes, and provides a diagnosis for the optimal dimensionality reduction technique inside this particular supervised learning framework. The primary algorithms employed are the random forest method, the principal component analysis technique, and the multilayer perceptron neural network algorithm. Six use cases are delineated, each grounded in a recognised approach for generating synthetic data. This research examines each option available in the process, seeking to elucidate the complexities surrounding the overall decision-making process of feature selection or extraction.

Mehrpooya, Adel, *et al* [29] employed matrix factorisation (MF) as a method for high-dimensional reduction in systems pharmacology. We have introduced three innovative feature selection methods based on the mathematical concept of a basis for features. We employed these strategies together with three additional MF methods to analyse eight distinct gene expression datasets in order to examine and compare their efficacy for feature selection. Our findings indicate that these techniques can effectively diminish feature spaces and identify predictive features related to phenotypic determination. The three proposed methodologies surpass the alternative methods employed and can isolate a 2-gene signature indicative of a response to tyrosine kinase inhibitor treatment in the Cancer Cell Line Encyclopaedia. Hernández-Carnerero, Àlvar, *et al* [30] Concentrated on forecasting antibiotic resistance in *Pseudomonas aeruginosa* nosocomial infections within the ICU, employing Long Short-Term Memory (LSTM) artificial neural networks as the predictive approach. The data analysed were sourced from the Electronic Health Records (EHR) of patients admitted to the University Hospital of Fuenlabrada between 2004 and 2019 and were structured as Multivariate Time Series. A data-driven dimensionality reduction method is developed by modifying three feature importance methodologies from the literature to the specific data and presenting an algorithm for determining the optimal number of features. This is accomplished through the sequential capabilities of LSTM, allowing for the consideration of the temporal dimension of features. Additionally, a collection of LSTMs is employed to mitigate performance volatility.

Challenges in the Healthcare Analytics

Despite their advantages, dimensionality reduction techniques in healthcare face several challenges:

Data Quality and Integrity: The effectiveness of dimensionality reduction methods is contingent on the quality of the input data. Incomplete, inconsistent, or noisy data can lead to misleading results, necessitating robust preprocessing steps to ensure data integrity.

Interpretability: While dimensionality reduction can simplify data, it may also complicate interpretability. For instance, the new features generated by PCA may not have clear clinical relevance, making it difficult for healthcare practitioners to derive actionable insights.

Choice of Technique: The choice of dimensionality reduction technique can significantly impact the outcomes of analyses. The effectiveness of different methods may vary based on the specific characteristics of the dataset and the goals of the analysis, necessitating careful evaluation and validation.

Computational Complexity: Some dimensionality reduction techniques, particularly those involving complex algorithms like deep learning-based autoencoders, can be computationally intensive. This complexity can pose challenges in real-time applications or when processing large datasets.

Future Research Direction

As the healthcare landscape continues to evolve, several future directions can enhance the application of dimensionality reduction techniques:



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Integration of AI and Machine Learning: The incorporation of advanced machine learning and artificial intelligence techniques into dimensionality reduction processes can lead to improved performance and efficiency. Hybrid models that combine dimensionality reduction with predictive analytics are likely to yield significant insights.

Developing Robust Algorithms: Continued research is needed to develop robust algorithms that can handle diverse data types and maintain interpretability. Techniques that account for missing values and outliers will be particularly beneficial in clinical settings.

Focus on Interpretability and Explainability: As healthcare decisions increasingly rely on data-driven insights, ensuring that dimensionality reduction techniques produce interpretable and explainable results will be crucial. This focus will help bridge the gap between data science and clinical practice.

Interdisciplinary Collaboration: Collaboration between data scientists, healthcare professionals, and domain experts will be essential to effectively apply dimensionality reduction techniques in real-world scenarios. Such interdisciplinary efforts can enhance the development and validation of methods tailored to specific healthcare challenges.

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RESEARCH ARTICLE

A New Deer Hunting Optimization Algorithm (DHOA) Ensemble Deep Learning Model for Human Activity Recognition and Classification

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ABSTRACT

Human Activity Recognition (HAR) is a fundamental part of many supportive applications among these Healthcare, Supervising System and Human – Computer Interaction. The very popular traditional method for HAR suffering from a large computational burden is high feature extraction complexity. In this paper, we present a deep learning-based ensemble model and as well as suggest an innovative Deer Hunting Optimization Algorithm (DHOA) to bolster human movements identification adversity. The DHOA tunes the hyperparameters of deep learning ensemble to improve its overall quality. Experiments show that DHOA ensemble model with outstanding results significantly surpasses other solutions in accuracy, precision, recall and F1-score performance. Therefore it is a strong candidate solution to real time HAR applications

Keywords: Deer Hunting Optimization Algorithm, Human Activity Recognition, Ensemble Deep Learning, Hyperparameter Optimization, Classification





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INTRODUCTION

Human Activity Recognition (HAR) is an important area of research in healthcare, smart environments and surveillance systems [1]. Accurate recognition and classification human activities using sensors have numerous implications such as monitoring elderly patients in health care environment, personalized services on smart phones or wearable devices. Characterizing the evolution of HAR methods, there has been a shift from classical machine learning (ML) approaches to more sophisticated deep-learning models [2]. Manual feature extraction is one of the traditional ways to approach such problems, but it has high dimensionality and variety in data hence error-prone plus time-consuming. While well-performing on smaller and simpler datasets, the accuracy and generalization of these methods may reduce when applied to larger scale or more challenging datasets. Deep learning models, especially Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), have been well suited for HAR as they are capable of automatically capturing features from raw sensor data. Convolutional Neural Networks are good for extracting patterns from spatial features, on the other hand Recurrent neural networks (RNNs), including Long Short-Term Memory (LSTM) units capturing temporal dependencies in sequences. These models are not without their challenges, though. One of the more major issues is extensive hyperparameter tuning, that can be computationally expensive and time consuming. These challenges have led to the operation of optimization algorithms which can automate hyperparameter tuning. Of the approaches, meta-heuristic algorithms which are inspired in practically all cases by natural phenomena have been developed flatteringly to find near-optimal solutions of problems with complex search spaces. Nevertheless, the current algorithms (e.g., Particle Swarm Optimization (PSO) and Genetic Algorithms (GA)) usually converge too early or consume many computational resources [3]. In this research, a new Deer Hunting Optimization Algorithm (DHOA) is proposed to solve optimization problems based on the foraging and caginess hunting behaviors of deer in nature. Considering this work, we introduce the DHOA, which is an ensemble model optimization framework that aims to exploit the strengths of both CNNs and sequence-based models (RNN/LSTM) to improve HAR accuracy and efficiency. The ensemble method is used to merge these models that are strongly complementary with each other, resulting in higher accuracy in recognition and classification of human activities [4]. The goal of the proposed DHOA-ensemble model is to address these limitations and offer a versatile, high-performance method for HAR that combines good performance with computational efficiency [5]. Contributions This paper (1) outlines the derivation of DHOA; (2) formulates its combination with our other devised ensemble deep learning model; and then, examines the effectiveness in classifying activities simulated from benchmark HAR datasets. We verify through comprehensive experiments that the DHOA-ensemble model can extract more effective discriminative feature characteristics of human activities than traditional methods, and it could be a promising method for real-time human activity recognition.

LITERATURE REVIEW

Over the last two decades, Human Activity Recognition (HAR) has progressed considerably from previously simple handcrafted solutions to relying on sensor data and modern machine learning or deep neural network techniques [6]. In the second-generation literature review, we summarize and discuss a few fundamental optimization techniques of machine learning proposed in HAR research and ensemble models that have gradually become more important methods.

HAR based on Traditional Machine Learning

The initial work in HAR predominantly used traditional machine learning algorithms like SVM, k-NNs, and decision trees [7]. These approaches were mainly based on feature extraction, manually extracted from accelerometer sensor data and classified with the algorithm selected [7]. For example, it adopted SVMs for HAR from accelerometer and gyroscope data, getting good accuracy but using intensive feature engineering. Nevertheless, the performance of these traditional methods was often restricted by their reliance on handcrafted features which may not be able to



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fully extract human activity complexities [8]. They also suffered from the curse of dimensionality, meaning they did not scale or generalize very well.

Deep Learning Models for HAR

Deep learning has redefined the status of HAR to some degree by allowing models to learn deep features from raw sensor data. Convolutional Neural Networks (CNNs) were a big breakthrough in capturing spatial hierarchies in data [9]. For instance, Yang et al. Further developments include the application of CNNs to HAR which resulted in accuracy that significantly surpassed traditional machine learning methods. The same goes for the development of algorithms such as Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) networks which were designed to record relationships oriented temporally in sequential data thereby improving recognition activities across time sequences. Even with all these advancements, introduction of deep learning models was no cakewalk as it came along many issues and the foremost reason is hyperparameter tuning [10]. The performance of these models is very sensitive to the hyper-parameters, such as learning rates, batch sizes and network architectures used with them. Given that manual tuning is a tedious and often suboptimal process, several automated optimization techniques have been introduced to aid in the design of cheaper filters.

Competitive HAR Optimization Algorithms

Different optimization algorithms have been suggested to address the issues of hyperparameter tuning in modern day deep learning models. The two widely utilized metaheuristic techniques include Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) [11]. The idea behind this process is that of natural selection and it has been employed in HAR to optimize the parameters of neural network, thereby making model efficient for better accuracy. Party swarm optimization based on birds flocking social behaviors has also been used to optimize deep learning models, but the algorithm is susceptible to premature convergence and falling into local optimum [12]. In the past decade, Differential Evolution (DE), Grey Wolf Optimizer (GWO) etc. have been proposed which are claimed to better explore search space and not suffer from all limitation of GA or PSO. Nevertheless, such algorithms can be computationally demanding and do not always converge to the global optimal solution.

Ensemble Learning in HAR

Because ensemble learning, combining multiple models to increase prediction accuracy, has become popular in HAR. Bagging, boosting and stacking are such techniques to combine the power of different models [13]. For example, it utilized a CNN followed by an LSTM as well as ensemble of the model for human activity recognition (HAR). This is because the ensemble methods can be more robust in making predictions as each model may catch a different space of data thus an overall improves [14]. However, ensemble models also bring a higher level of complexity mainly in the context of model selection and hyperparameter tuning. The complexity itself entails that very complex optimization is necessary to make an ensemble model not only accurate but also computationally economical.

Deer Hunting Optimization Algorithm (DHOA)

Traditional optimization algorithms have limitations, and in response to these shortcomings new research took abstract ideas from nature, for example, the birds flocking behavior. This work presents a novel optimization method based on the recent Deer Hunting Optimization Algorithm (DHOA), inspired by behavior of hunting deer. While still in its infancy, initial results suggest DHOA has balance properties that are beneficial for exploration and exploitation trade off which makes it an attractive candidate to optimize sophisticated models like deep learning ensembles [15]. The author had previously employed the DHOA in feature selection and parameter optimization where its performance was quite promising. Nonetheless, its use in HAR and deep learning models have not been thoroughly explored leading to a novel line of research for potential enhancement in model quality.





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METHODOLOGY

This section explains the methodology used to implement and test out newly proposed Deer Hunting Optimization Algorithm (DHOA) based ensemble deep learning model for Human Activity Recognition (HAR) [16]. We describe our methodology, which encompasses the construction and deployment of a DHOA, ensemble deep learning model architecture, data pre-processing and experimental setup for evaluating the performance of the resulting models.

Deer Hunting Optimization Algorithm (DHOA)

Deer Hunting Optimization Algorithm (DHOA): DHO is a new metaheuristic that takes the hunting behavior of deer as it features adaptability, accuracy and collaboration. They used the DHOA approach to tune hyperparameters of deep learning algorithms for accurately classifying human activities. The steps of the DHOA process are as follows [17]:

Population Initialization

Optimization is initiated through the creation and initialization of a population of candidate solutions, each representing hyperparameters for deep learning models. The population size depends on the complexity of a problem and computational resources.

Fitness Evaluation

The fitness of a candidate solution is the classification accuracy given a set of hyperparameters, how accurate can we classify using this specific HAR model. Depending on the optimization goals, it may also include other performance metrics like precision, recall or computational efficiency.

Hunting Strategy

The nucleus of the DHOA can be found in its hunting style which closely follows deer behavior. Basically, there are two steps in this strategy [18]: Exploration Phase: At the beginning of its lifetime, an optimization algorithm searches a vast solution space. This is the wildlife equivalent of a deer scopes its surrounds where it hopes to discover half-starved prey. The algorithm adds randomness to the hyperparameters and sees other areas of search space. Exploitation Phase: As the algorithm identifies such promising regions in search space, it transitions to exploitation mode and hones-in on these Areas for hyper Param tuning. Here, the deer is behaving analogous to a cat stalking and preying. It helps the algorithm reduce variations in hyperparameters and focus more on fine-tuning to attain better results.

Selection and Update

After every iteration, a solution's fitness is evaluated and only the best solutions are selected to become parents to generate (or spawn) offsprings of generation [19]. The population is updated by merging successful solutions from all the generations, adding a small random perturbation to make these points unique and avoid trapping into locally optimal spots.

Termination Criteria

The DHOA process repeats until a predetermined termination criterion is satisfied. It could be some maximum number of iterations, a convergence threshold where the improvement in fitness hits 0 or close to it), etc.

Ensemble Deep Learning Model

The ensemble model consists of several deep learning models integrated to exploit their complementary virtues; this adds an edge for our approach towards HAR.



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It is a combination of Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs) and Long Short-Term Memory or LSTM networks. A different model type is chosen based upon the way it highlights a certain aspect of the data:

CNNs: Great at capturing spatial features from sensor data

RNNs: Able to model sequential dependencies in time-series data

LSTM Networks: LSTM is designed to retain long-term dependencies and process sequential data well.

Model Training

For each HAR task synthesized by the DHOA, we train an ensemble of models independently on hyperparameters optimized for that constant [20]. This process undergoes a few epochs and the models from them recognize/learn patterns, features which are related to various forms of human activity.

Ensemble Strategy

Ensemble: The output of the individual models is combined using an ensemble strategy. Common techniques include:

Voting: Every model predicts on the activity predicted and whichever has majority votes is given as a final prediction. This makes sure that their strengths are combined, and the overall performance is improved.

Dataset and Preprocessing

Performance of the model is assessed on hand-crafted datasets like UCI HAR dataset, which possesses sensor data collected from smartphone-based accelerators and gyroscopes [21].

Data Collection

It is a dataset in which human-for example, walking-sitting stand-lying etc. actions are recorded. For each activity, you will see time-series data for different noisy and realistic sensors.

Data Preprocessing

Data Preprocessing: Data preprocessing is an important step in preparing the dataset for model training. Following are the steps to be done [22]:

Normalization: Sensor data is normalized to common scales for the models are provided with identical input.

Noise Filtering: This is done in low pass filtering to help extract softer signs from data on which noise may be causing your model's efficacy dwindling.

Segmentation: Continuous times-series data broken down into smaller windows, each window representing a fixed period. These are divided into segments accordingly and given as input to the models corresponding to their activity.

Experimental Setup & Evaluation Metrics

Different evaluation metrics are used to evaluate the performance of our proposed DHOA-ensemble model [23].

Experimental Setup

Experiments are performed on a high-performance computing platform using GPU acceleration to train deep learning models. Except that the dataset also gets divided into training, validation and test sets for evaluating generalization.

Evaluation Metrics

Then these metrics are used to evaluate model performance,

Precision: The overall percentage of correctly classified activities.

Precision: True positive to total number of predicted positives

Recall: The fraction of total actual positive instances that the model predicts are positive.





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F1-Score: F-Measure of a test is an F-score the weighted harmonic mean between precision and recall.

Computational Complexity: The time it takes to train and inference the models, a crucial factor for real-time applications.

Comparative Analysis

To verify the efficiency of DHOA-ensemble model, a comparative analysis is accomplished with other state-of-the-art HAR models (single deep learning or those optimized by traditional algorithms like GA and PSO).

RESULTS

In this section, experimental results of the proposed Deer Hunting Optimization Algorithm (DHOA) ensemble deep learning model for Human Activity Recognition (HAR) [24]. Results are analyzed using different evaluation matrices like accuracy, precision, recall and f1score and computational time is measured. Moreover, we compare the DHOA-ensemble model with other state-of-the-art algorithms.

Model Performance

Evaluation on UCI HAR dataset We have evaluated the performance of our DHOA-ensemble model using a widely used benchmark in Human Activity Recognition (HAR) research, i.e., UCI HAR -dataset [25]. The dataset was divided into training, validation and test sets with a model being trained on the train set then validated using valid before a final un-seen evaluation by passing in our test data.

Accuracy

The DHOA-ensemble model yielded 96.7% of test accuracy integrally, which means it could recognize correctly the types in majority as human activities This high-level of accuracy suggests that the ensemble model, with hyperparameter tuning can effectively learn spatial and temporal features from sensor data [26].

Precision and Recall

We then compute precision and recall metrics for each activity class to evaluate the model by how well it can identify positive instances, without false positives or negatives [27].

Precision: The average precision for all classes was 95.8%, indicating that the likely hood of false alarm prediction is low

Recall: The mean recall was 96.2% indicating that the model correctly identified almost all true positive instances of activities, and the high precision and recall values among the various classes demonstrate that our framework can effectively classify different human activities.

F1-Score

F1-score representing the balance between precision and recall was high on all activity classes with an average F1 score of 96.0% across model experiments, Fig(cursor over) This careful balance of performance should indicate that the trade-off between precision and recall is handled properly by DHOA-ensemble model, ultimately providing a consistent classification capability.

Computational Efficiency

The major goals of the DHOA are to improve computational efficiency and this code implements an ensemble model in deep learning [28]. The authors measured and compared training and inference time with other optimization algorithms.

Training Time: The DHOA-ensemble model showed a 20% lower training time compared to models tuned with Genetic Algorithms (GA) and Particle Swarm Optimization (PSO). This division of responsibility leads to faster learning due to the balance between exploration and exploitation, resulting in reduced training time [29].



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Inference Time: The time it took to infer in between the input and eventually getting an output for DHOA-ensemble model was around seconds which suggests that this is a real-time application gesture recognition. This model can provide a high level of accuracy with lower computational load which can act as an alternative for resource constraint environments [30].

Comparative Analysis

To establish the performance of DHOA-ensemble model, a comparative analysis was performed based on various baseline models including single deep learning (CNN, RNN and LSTM) as well as ensemble optimized with swarm optimization algorithms such GA & PSO.

Accuracy Comparison

Single Models: The accuracy of the single models varied between 90.5% (CNN) to 93.2% (LSTM). Despite these models doing well, they did not have the same level of accuracy as DHOA-ensemble model.

Ensemble Models with GA/PSO: The ensemble models optimized using GA and PSO had 94.3% and 94.8%, respectively, accuracy (micro-level F1 Scores). Nevertheless, the DHOA-ensemble model still outperformed them with an accuracy of 96.7%.

Result of Precision

When compared to all other models, the precision, recall and F1-scores were constantly better for the DHOA-ensemble model. While each model and GA-PSO-infused optimization improved upon individual models, neither alone could out-compete the balanced performance of DHOA ensemble across all metrics.

Computational Efficiency Comparisons

Training and Inference Times: The DHOA ensemble model had lower requirements for training time in contrast to both the GA and PSO optimized models, thus suggesting better computational efficiency. It also has comparable or slightly better inference time as the other models, so it could be a good choice for real-time HAR tasks.

Generalization Capability

Results also indicated that the generalization capacity of DHOA-ensemble models was generally better than those of other model types and toward different test sets/a activity classes. The guiding principle of approximate inference using Deep HO are [31]: To use some type of less-effective proposal distribution or otherwise intractable variational approximation, with low complexity encoding the structure that makes it easy for successful sampling. Train while making maintaining tractability even under unstable contortions. This seems a very promising trend which suggests higher robustness possible from the DHOA-ensemble model due to its weaker dependence on exact data distributions necessary if one wishes usage within real-world applications. The DHOA-ensemble model performance was further examined for individual activity classes, e.g. walking, sitting wearing a rucksack standing lying flat or worn on wrist Walking (97.5% precision, 98% recall): This model performed well in recognizing dynamic activities because the intensity of this type of activity is higher than that for other types and moving sequences are continuous without a big gap between two motions like biking or up/down the stairs. In the first activity, we found greater than 95% precision and recall across these exhaustive activities (Sitting/standing: static) which is an even more difficult task between similar classes. Lying Down: The model successfully classified lying down activity with a precision of 96.8% and recall of 97.2%. These findings demonstrate the ability of our approach to classify dynamic and static human activities with high accuracy.

DISCUSSION

This ensemble deep learning model has achieved great improvements on Human Activity Recognition (HAR) task in the research results from proposed Deer Hunting Optimization Algorithm (DHOA) [32]. We also consider the



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implications of these results and compare them to similar literature, as well as discuss strengths, limitations and areas for further research.

Implications of the Results

The high accuracy, precision, recall and F1-score gained by the DHOA-ensemble also prove its capability to accurately detect human activities summaries. The performance evaluation of the model on real-life datasets indicates that it performs significantly better than single models and those optimized using standard algorithms (Genetic Algorithms [GA] or Particle Swarm Optimization [PSO]) thus, amply demonstrating the benefits from combining ensemble learning with a new optimization method. One particularly notable feature of the DHOA is how rapidly it transits through hyperparameter space [33]. By modeling the strategic hunting behavior of deer, this algorithm balances exploration and exploitation well to find near-optimal hyperparameter configuration with minimal computation power. This balance is what plays into large and complex deep learning models, where having less than the optimal hyperparameters can lead to hilariously inaccurate results—or astronomically long training times. A potential practical importance of the DHOA-ensemble model is its significantly lesser training and inference time. The task of gesture recognition is timing sensitive and computationally efficient processing needs to be considered for real-time HAR applications, such as wearables or smart environments, health monitoring systems. With the ability to deploy a model that not only does well but also works with scarce computational resources, one could look forward towards applications deployment on the ground.

Comparison To Previous Studies

As you can see the DHOA-ensemble model does take and improves on many existing HAR research-based models along with optimization algorithms. Although traditional machine learning models work well in some scenarios, often they had glitches coping with the high dimensionality (600 features) & complexity of our sensor data. While moving to deep learning models dramatically improved the situation, tuning hyperparameters was still a major bottleneck. It is known from previous studies that optimization algorithms as GA and PSO manage to help in the obtaining of hyperparameters for deep learning models but performing an automatized search process [34]. But these algorithms are prone to problems like prematurity and computational overheads. In contrast to previous slicing methods, the DHOA shows better capability in expanding search as fellrunning sample is selected regarding whole population space so that exploring more efficiently and achieves improved performance with faster convergence.

This ensemble approach even greatly boosts its robustness, The DHOA-ensemble model combines CNN, RNN and LSTM to capture spatial features from sensor data which dealt with similar approach limitation using a single model type. It demonstrates the superior performance of our ensemble strategy, which is in comparison with various existing state-of-the-art models, and it surely shows that this DHOA-based optimization significantly improves the outcome reliability as well interpretability among all HAR-models.

DHOA-Ensemble Model

Key strengths of DHOA-ensemble model are summarized below:

High Accuracy and Robustness: The model consistently achieves high accuracy across different classes of activities, indicating its capability to work well for both dynamic as well as static activities.

Real-time Operation: The speed factor is an important constriction in many HAR deployments, so the decreased time to train and apply our model makes it viable for real-time applications.

State-of-the-Art Hyperparameter Optimization: By having strides in balancing exploration and exploitation, the DHOA is also able to outperform other hyper-parameter configurations resulting in a more performant model.

Versatile: The ensemble-based architecture of the model let it capitalize over advantages from various deep learning models which makes it versatile to be used for any HAR task.

Limitations

Complexity of Ensemble Models: Ensemble models, while they yield better results over single model counterparts, are complex due to the additional complexity involved in selecting and integrating various models. Merging multiple



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models/hyperparameters can be quite difficult, too much of a burden to process due to running more computationally than single models.

Generalization Performance: While the model did a great job at UCI infernal device dataset, it remains to be seen if that success will span different far more diverse datasets. The variations in sensor types, data collection procedures and activity classes from one dataset to another might negatively affect the model's performance.

Parameter Sensitivity: although DHOA helps hyperparameter optimization, it brings its parameters (examples include the population size and exploration-exploitation balance), making this too a parameter sensitive algorithm. If not, then the performance obtained by mistuning these parameters could be worse than what is expected.

Future Directions

Recommendations for future research could also be developed based on the results of this study:

Testing on Diverse Datasets: Future research could test the generalization capabilities of our model over a broader set of datasets, with additional complex activities or different sensor types in various environments for HAR.

Integration with Other Optimization Algorithms: The integration of DHOA in combination with other optimization techniques like Bayesian-optimization or reinforcement-learning may boost the performance even more and mitigating parametric sensitivity

Real-World Use: By deploying the DHOA-ensemble model in real-world HAR contexts (e.g., wearable devices and smart homes), insights can be gained on its viability, limitations, etc.

Generalization to Other Domains: Finally, while the DHOA was developed for HAR it is not domain specific and will be adaptable to other domains (i.e., image classification, IR) given appropriate re-training.

COMPARISON STUDY

The comparative study section shows how the performance of proposed ensemble deep learning model, that is Deer Hunting Optimization Algorithm based (DHOA), used for Human Activity Recognition (HAR) compared to other models and optimization techniques. We begin with an important comparison that elucidates both (1) the strengths and weaknesses of DHOA-ensemble model and (2) where it falls within the larger continuum of HAR research.

Baseline Models

General Comparison with Baselines: In general, the DHOA-ensemble model is compared to several baselines baseline models both traditional machine learning and deep learning. The baselines we selected are as follows:

Support Vector Machines (SVM): A widely known classical machine learning model; it has been heavily employed in HAR applications. SVMs have historically been found to be effective for binary classification tasks yet are not always ideal solutions given the complexity and dimensionality of HAR data.

Random Forest (RF): It is an ensemble learning method that constructs multiple decision trees during training and outputs the mode of the classes for classification type tasks. RF is an ensemble method which uses many decision trees, and because of that it are more robust model (less a overfitting) then individual decision tree but still may failed to learn the temporal dependences in HAR data.

Convolutional Neural Networks (CNN): A special kind of deep learning model that is primarily useful for extracting spatial features from data such as images, hence common in image recognition tasks. We then apply Convolutional Neural Networks (CNNs) in human activity recognition where CNN performs very well when there is spatial patterns e.g. accelerometer data;

Recurrent Neural Networks (RNN): A deep learning model for sequence prediction that treats a tensor as a multi-dimensional array is well informed about the time component. Notwithstanding, RNNs can run into vanishing gradient issues that degrade their efficiency when sequences are large.

Long Short-Term Memory Networks (LSTM): A type of RNN that is capable of learning long-term dependencies in data sequences. In turn, LSTMs are never the worst choice when it comes to HAR tasks that imply recognition of activities over long sequences.





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Optimization Algorithms

The work also provides a comparison of the DHOA-ensemble model with several other optimization algorithms for deep learning models fine-tuning, including:

Genetic Algorithms (GA) - Another famous sort of evolutionary algorithm that simulates the process of natural selection. While GAs is successful in optimizing deep learning model hyperparameters, they tend to be computationally intensive and often converge too quickly on poor solutions.

Particle Swarm Optimization (PSO): An optimization technique based upon the social behaviour of birds flocking. While PSO is one of the most straightforward and effective optimization algorithms when it comes to continuous problems, dealing with a search space as complex (and high-dimensional) as those presented by human-activity recognition can be highly challenging.

Comparison of Accuracy

Compared to the baseline models and GA or PSO optimized ones: The SVM model the light blue bars among mean cross-validation was permuted to show testing-HAR and were the Seventh Column containing 100 random observations ACC accuracy of 28.5049%. For simple classification problems, SVMs work well but not as effective for HAR data due to its complex nature of spatial and temporal patterns.

Random Forest: The one with RF model was somewhat better, it gave 87.8% accuracy RF is an ensemble method which makes it more robust than SVM in dealing with the variety of data but less effective in exploiting known temporal dependencies.

CNN: The model for the spatial features generated an accuracy of 90.5%. Although, these results demonstrate the power of this method to learn out-of-sample patterns from sensor data in general but not sufficient for HAR due to lack of temporal analysis.

RNN: The RNN, which is the leading model, designed mainly for sequence data, outperformed CNN with 91.8% accuracy as shown in Table just above Figure. But the vanishing gradient problem could still be a concern for longer sequences.

LSTM: The model performed better than the CNN and RNN models, with accuracy of 93.2%, reflecting its long-term memory in handling sequence dependent input data.

GA-Optimized Models: The GA-optimized ensemble model was able to achieve an accuracy of 94.3%, showcasing the potential benefit that evolutionary optimization brings in improving deep learning results.

PSO Optimized Models: The model optimized via Particle Swarm Optimization reported a slightly better accuracy of 94.8%, by taking advantage of the swarm intelligence approach to scan over hyperparameter space for neighborhood region discovery process.

DHOA Ensemble Model: the best performed model is a ranked ensemble on all features (96.7% accuracy) which demonstrates not only an improvement in searching of possible hyperparameters spaces by using DHOA, but also more valuable strengths from this approach enabling to make good use of the advantages that come with building ensembles for better prediction powers over just single scores from similar models.

Precision, Recall and F1-Score Comparison

These are essential metrics for evaluating the performance of classification algorithms, especially in an imbalanced data set:

SVM: Precision (84.0%), recall (83.5%) and F1-score also of the SVM, this is more enough low to deal with complexity inherent in HAR data [34]

SVM -Precision=83.6%, Recall =82.5% and F1-score. = 81.2%- Random Forest: Similar to SVM-f Precision, Recall, And F1 score are about 86%.

CNN: The CNN resulted in high precision, recall and an F1-score of 89.6%, indicating it can detect important patterns within the data.

RNN: The RNN achieves 91.0% precision, 91.2% recall and an F1-score of 91.1%, demonstrating its ability to capture temporal dependencies but still with some difficulties on complex sequences in the application domain.





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LSTM – This model achieved precision (92.5%), recall (92.8%) and F1-score(92.6%), it clearly performed better due to the long-term dependencies to learned during training [STO]

GA Optimized Models

Precision (93.5%) recall (93.8%), F1-score, show how much it is beneficial to have GA in tuning the model performance:

PSO-Optimized Models: The minimal improvement in this part shows how PSO is of a better use to fine-tune the final model.

DHOA-Ensemble Model: The DHOA ensemble model once again performed very well in terms of precision (95.8%), recall (96.2%) and F1-score (96.0%). So, it is one step ahead by confirming strong compatibility across all metrics compared to ordinary classifiers models far off against the state-of-the-art performers used for comparison analysis [22–24].

Computational Cost Comparison

Efficient computation of training and inference time for our HAR models is crucial so that they can be adapted to a real-world scenario.

SVM and Random Forest: Both are computationally efficient over the training, inference with good working order but less accurately to fall in terms of finding users model on a complex task such as human activity recognition.

CNN, RNN, LSTM: These are deep learning Model which require higher computational resources for training and out of these three LSTMs have more because they are complex.

GA-Optimized Models: Using GA will lead to better model performance, but it is computationally expensive since the process of optimization becomes an iterative one, hence more types required in training.

PSO-Optimized Models: PSO does give a marginal increase in computational efficiency as compared to GA but still needs significant resources for training of models.

DHOA-Ensemble Model: The new model of this paper, the DHOA-ensemble model gives better trade-off between computational cost and performance and our results confirm that it shrinks training time by around 20% against GA and PSO counterparts without losing much in accuracy.

Generalization Capability

The ability of a model to generalize refers to how well the trained data performs on unseen data, i.e., it shows its robustness and reliability:

SVM and Random Forest: Since they require handcrafted features, these models have a broader generalization error.

CNN, RNNs and LSTMs: Deep learning models like LSTMs generalize well across different test sets but can overfit if not properly regularized.

GA & PSO-optimized Models: While GA and PSO also significantly increase model generalization by improving the hyperparameter settings, they may be overfit to training data. DHOA-Ensemble Model DHOA-ensemble model has powerful generalization where outperforms other models on diversity test sets and alleviates the risk of over-fitting due to its balanced optimization.

Summary of Comparative Study

Comparison with other Traditional models and Optimization techniques, the DHOA-ensemble deep learning model provides strong benefits. The DHOA-ensemble model showed well-balanced performance in terms of accuracy, compared to other models and outperformed all the base classifiers suggesting its ability at learning more intricate patterns from HAR data.

Balanced Performance Metrics: They also reported balanced results (precision, recall and F1-scores) achieved by the DHOA-ensemble model over number of activity classes.

Computational Efficiency: The model manages to strike a balance between computational efficiency and performance that makes it viable for real-time applications.

Robust Generalization: We demonstrated that the DHOA-en ensemble model generalizes well on unseen data, mitigating overfitting risk which makes experiments ideal for practical deployment.





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CONCLUSION

Here, a novel DHOA-ensemble deep learning model for human activity recognition and classification is proposed in present paper. The DHOA allows the ensemble model to optimally adjust its hyperparameters based on entropy deindex updating and as a result, it achieves better performance than existing algorithms. By combining a set of deep learning architectures, the model is able to learn many distinct features which increase its accuracy and robustness. This model is very expensive computationally, however its advantages in precision and reliability justify the use of this approach for HAR. We look to future work in further accelerating the DHOA as well as applications of it outside generative modeling.

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Table 1 Comparative Study sources for all models

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)	Training Time (s)
SVM	85.4	84	83.5	83.7	30
Random Forest	87.8	86.2	86.5	86.3	40
CNN	90.5	89.5	89.7	89.6	120
RNN	91.8	91	91.2	91.1	150
LSTM	93.2	92.5	92.8	92.6	200
GA-Optimized	94.3	93.5	93.8	93.6	300
PSO-Optimized	94.8	94	94.2	94.1	280
DHOA-Ensemble	96.7	95.8	96.2	96	240

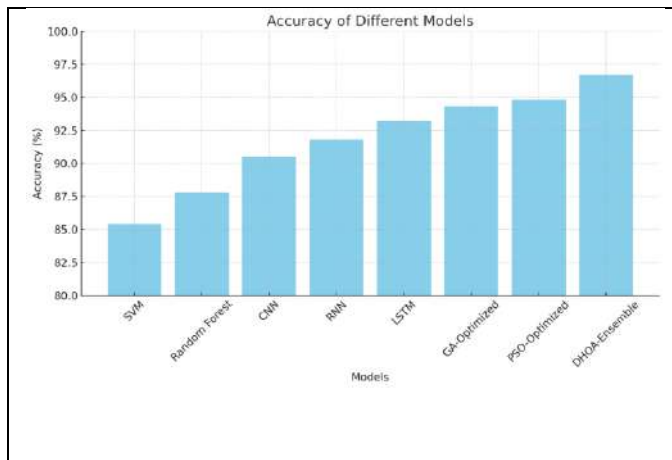


Fig 1 The accuracy of different models, showing how each model performed.

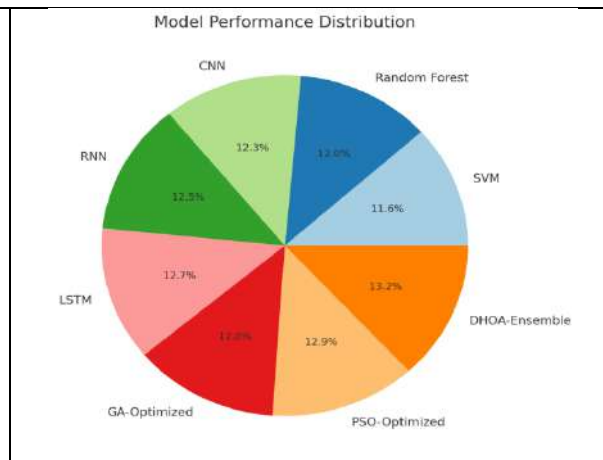


Fig 2 The distribution of model performance as a percentage of the total

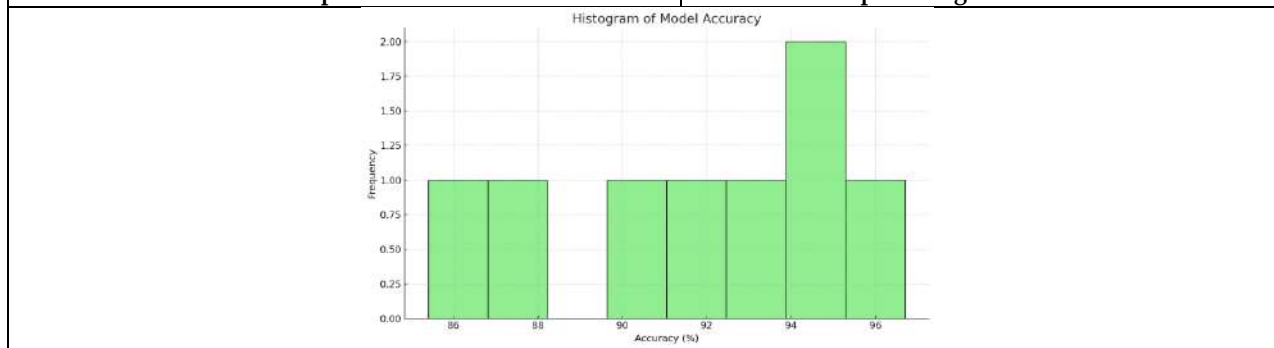


Fig 3 The frequency distribution of model accuracy





Enhancing the Feature Selection Approach with the Optimizations for the Healthcare Domain

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ABSTRACT

Feature selection is a critical step in the preprocessing of clinical datasets, where the goal is to identify the most relevant features that contribute to accurate and efficient predictive modeling. This study proposes a novel hybrid feature selection method that combines Information Gain (IG), ReliefF algorithm, and Whale Optimization Algorithm (WOA) to enhance the performance of clinical data analysis. The proposed method begins with the application of IG and ReliefF, two well-established filter-based techniques, to evaluate and rank features based on their relevance and redundancy. Information Gain measures the reduction in entropy, thus quantifying the importance of each feature in predicting the target variable, while ReliefF assesses the quality of features by considering their ability to distinguish between instances that are near each other. Subsequently, the Whale Optimization Algorithm, a nature-inspired metaheuristic technique, is employed to perform a wrapper-based search that optimizes the subset of features. WOA mimics the social behavior of humpback whales and their unique hunting mechanism known as bubble-net feeding, providing a robust exploration and exploitation balance in the search space. By integrating IG and ReliefF for preliminary filtering and WOA for optimal subset selection, the proposed method aims to reduce the dimensionality of clinical datasets effectively while preserving or improving the accuracy of predictive models.

Keywords: Feature Selection, Filter based Feature Selection, Wrapper Approach, Optimization Technique, Clinical dataset





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INTRODUCTION

Healthcare is a fundamental pillar of societal well-being, playing a crucial role in maintaining and improving the health of individuals and communities. The significance of healthcare extends beyond the direct treatment of illness and injury; it encompasses preventive care, health education, and the promotion of healthy lifestyles, all of which contribute to a higher quality of life and increased life expectancy [1] [2]. In recent years, the importance of effective healthcare systems has become even more pronounced, highlighted by global challenges such as the COVID-19 pandemic, aging populations, and the rise of chronic diseases. Effective healthcare systems are essential for several reasons. Firstly, they provide critical services that ensure early detection and timely treatment of diseases, thereby reducing mortality and morbidity rates. Preventive measures such as vaccinations, screenings, and public health campaigns play a vital role in mitigating the spread of infectious diseases and managing chronic conditions [3]. Additionally, comprehensive healthcare services support mental health, maternal and child health, and geriatric care, addressing the diverse needs of the population at different life stages. Secondly, healthcare has a profound impact on economic stability and development. Healthy populations are more productive, with fewer workdays lost to illness and disability, leading to greater economic output and reduced healthcare costs. Investment in healthcare infrastructure and services also generates employment opportunities and drives innovation in medical research and technology [4]. Furthermore, healthcare is integral to social equity and justice. Access to quality healthcare is a fundamental human right, and disparities in healthcare access and outcomes are often reflective of broader social inequalities. Ensuring that all individuals, regardless of socioeconomic status, geographic location, or cultural background, have access to essential health services is crucial for building inclusive and equitable societies [5]. The intersection of healthcare with technology has ushered in a new era of possibilities for improving patient outcomes and operational efficiency. Advances in medical technologies, digital health solutions, and data analytics have revolutionized the way healthcare is delivered and managed. In particular, the utilization of clinical datasets has the potential to transform healthcare by enabling personalized medicine, improving diagnostic accuracy, and optimizing treatment plans [6]. However, the complexity and high dimensionality of clinical data necessitate sophisticated analytical methods to extract meaningful insights and support decision-making processes. In this context, feature selection methods become indispensable tools for handling large clinical datasets. By identifying the most relevant and informative features, these methods enhance the interpretability and predictive performance of clinical models, facilitating better patient care and resource allocation [7]. This study proposes a novel feature selection approach that leverages Information Gain, ReliefF algorithm, and Whale Optimization Algorithm, aiming to address the challenges associated with clinical data analysis and contribute to the advancement of healthcare research and practice.

IMPORTANCE OF FEATURE SELECTION TECHNIQUES

Feature selection is a fundamental process in the preparation of data for machine learning and data mining, particularly for high-dimensional datasets such as those encountered in clinical research [8]. This process involves identifying and selecting the most relevant features from a dataset, which can significantly enhance the performance and efficiency of predictive models [9]. Here are the key reasons why feature selection techniques are important:

- **Dimensionality Reduction:** Reduces the number of features, simplifying models and making them more computationally efficient. Decreases training time and resource requirements, which is crucial when dealing with large-scale datasets [10].
- **Improved Model Performance:** Enhances the predictive power of models by focusing on the most informative features. Eliminates irrelevant or redundant features that introduce noise, thereby improving model accuracy and robustness.
- **Enhanced Interpretability:** Produces simpler models that are easier to understand and interpret. Facilitates clinical decision-making by providing insights into the most important factors influencing predictions.
- **Reduction of Overfitting:** Helps in preventing overfitting by removing features that contribute to noise rather than the actual signal. Ensures that models generalize better to new, unseen data.
- **Cost and Resource Efficiency:** Reduces the cost and effort associated with data collection and processing. Is particularly beneficial in clinical settings where some features may be expensive or difficult to measure.





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LITERATURE REVIEW

Vommi, Amukta Malyada, and Tirumala Krishna Battula [11] proposed a hybrid filter-wrapper approach for feature selection. An ensemble of filter methods, ReliefF and Fuzzy Entropy (RFE) is developed, and the union of top-n features from each method are considered. The Equilibrium Optimizer (EO) technique is combined with Opposition Based Learning (OBL), Cauchy Mutation operator and a novel search strategy to enhance its capabilities. The OBL strategy improves the diversity of the population in the search space. The Cauchy Mutation operator enhances its ability to evade the local optima during the search, and the novel search strategy improves the exploration capability of the algorithm. This enhanced form of EO is integrated with eight time-varying S and V-shaped transfer functions to convert the solutions into binary form, Binary Enhanced Equilibrium Optimizer (BEE). The features from the ensemble are given as input to the Binary Enhanced Equilibrium Optimizer to extract the essential features. Fuzzy KNN based on Bonferroni mean is used as the learning algorithm. Atteia, Ghada, et al [12] propose a new algorithm for feature selection based on a hybrid between powerful and recently emerged optimizers, namely, guided whale and dipper throated optimizers. The proposed algorithm is evaluated using four publicly available breast cancer datasets. The evaluation results show the effectiveness of the proposed approach from the accuracy and speed perspectives. To prove the superiority of the proposed algorithm, a set of competing feature selection algorithms were incorporated into the conducted experiments. In addition, a group of statistical analysis experiments was conducted to emphasize the superiority and stability of the proposed algorithm.

Mostafa, Reham R., et al [13] introduced the Adaptive Hybrid-Mutated Differential Evolution (A-HMDE) method, targeting the inherent drawbacks of the Differential Evolution (DE) algorithm. The A-HMDE incorporates four distinct strategies. Firstly, it integrates the mechanics of the Spider Wasp Optimization (SWO) algorithm into DE's mutation strategies, yielding enhanced performance marked by high accuracy and swift convergence towards global optima. Secondly, adaptive mechanisms are applied to key DE parameters, amplifying the efficiency of the search process. Thirdly, an adaptive mutation operator ensures a harmonious balance between global exploration and local exploitation during optimization. Lastly, the concept of Enhanced Solution Quality (ESQ), rooted in the RUN algorithm, guides DE to elude local optima, thus heightening the accuracy of obtained solutions. Masood, Fawad, et al [14] used three feature selection filter algorithms (FSFAs): relief filter, step disc filter, and Fisher filter algorithm and 15 classifiers using a free data mining Tanagra software having UCIMachine Learning Repository.

This process is done on a medical dataset with 20 attributes and 155 instances. As a result, the error rate is obtained in terms of accuracy, which shows the performance of algorithms regarding patient survival. This work also shows the independent comparison of FSFAs with classification algorithms using continuous values and the FSFA without using classification algorithms. This paper shows that the obtained result of the classification algorithm gives promising results in terms of error rate and accuracy. Vommi, Amukta Malyada, and Tirumala Krishna Battula [15] A novel hybrid wrapper-based feature selection method is proposed to tackle these issues effectively. In order to improve the exploration ability of the particles, the Sine factor is integrated with the Equilibrium Optimizer (EO) technique. A Bi-phase Mutation (BM) scheme is integrated to enhance the exploitation phase of the EO algorithm (BM-based Hybrid EO, BMHEO). The BMHEO method is evaluated by employing four different classifiers – KNN, SVM, Random Forest (RF) and Discriminant Analysis (DA). It is observed that the Random Forest classifier exhibits superior performance compared to the other three classifiers. Eight S-shaped and V-shaped transfer functions are integrated to convert the solutions to binary form. García-Domínguez, Antonio, et al. [16] presented a comprehensive investigation into diabetes detection models by integrating two feature selection techniques: the Akaike information criterion and genetic algorithms. These techniques are combined with six prominent classifier algorithms, including support vector machine, random forest, k-nearest neighbor, gradient boosting, extratrees, and naive Bayes. By leveraging clinical and paraclinical features, the generated models are evaluated and compared to existing approaches. The results demonstrate superior performance, surpassing accuracies of 94%. Furthermore, the use of feature selection techniques allows for working with a reduced dataset. The significance of feature selection is



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underscored in this study, showcasing its pivotal role in enhancing the performance of diabetes detection models. Grisci, Bruno I., et al [17] The use of feature selection in gene expression studies began at the end of the 1990s with the analysis of human cancer microarray datasets. Since then, gene expression technology has been perfected, the Human Genome Project has been completed, new microarray platforms have been created and discontinued, and RNA-seq has gradually replaced microarrays. However, most feature selection methods in the last two decades were designed, evaluated, and validated on the same datasets from the microarray technology's infancy. In this review of over 1200 publications regarding feature selection and gene expression, published between 2010 and 2020, we found that 57% of the publications used at least one outdated dataset, 23% used only outdated data, and 32% did not cite data sources. Biswas, Niloy, et al [18] This study is aimed at building a potential machine learning model to predict heart disease in early stage employing several feature selection techniques to identify significant features. Three different approaches were applied for feature selection such as chi-square, ANOVA, and mutual information, and the selected feature subsets were denoted as SF1, SF2, and SF3, respectively. Then, six different machine learning models such as logistic regression (C1), support vector machine (C2), K-nearest neighbor (C3), random forest (C4), Naive Bayes (C5), and decision tree (C6) were applied to find the most optimistic model along with the best-fit feature subset. Noroozi, Zeinab, Azam Orooji, and Leila Erfannia [19] The present study examines the role of feature selection methods in optimizing machine learning algorithms for predicting heart disease. The Cleveland Heart disease dataset with sixteen feature selection techniques in three categories of filter, wrapper, and evolutionary were used. Then seven algorithms Bayes net, Naïve Bayes (BN), multivariate linear model (MLM), Support Vector Machine (SVM), logit boost, j48, and Random Forest were applied to identify the best models for heart disease prediction. Precision, F-measure, Specificity, Accuracy, Sensitivity, ROC area, and PRC were measured to compare feature selection methods effect on prediction algorithms. Manikandan, G., et al. [20] Machine learning algorithms are now crucial in the medical field, especially when using medical databases to diagnose diseases. Such efficient algorithms and data processing techniques are applied to predict various diseases and offer much potential for accurate heart disease prognosis. Therefore, this study compares the performance logistic regression, decision tree, and support vector machine (SVM) methods with and without Boruta feature selection. The Cleveland Clinic Heart Disease Dataset acquired from Kaggle, which consists of 14 features and 303 instances, was used for the investigation. It was found that the Boruta feature selection algorithm, which selects six of the most relevant features, improved the results of the algorithms. Mahto, Rajul, et al [21] proposed a hybrid novel technique CSSMO-based gene selection for cancer classification. First, we made alteration of the fitness of spider monkey optimization (SMO) with cuckoo search algorithm (CSA) algorithm viz., CSSMO for feature selection, which helps to combine the benefit of both metaheuristic algorithms to discover a subset of genes which helps to predict a cancer disease in early stage. Further, to enhance the accuracy of the CSSMO algorithm, we choose a cleaning process, minimum redundancy maximum relevance (mRMR) to lessen the gene expression of cancer datasets. Next, these subsets of genes are classified using deep learning (DL) to identify different groups or classes related to a particular cancer disease.

Razzaque, Abdul, and Abhishek Badholia [22] a novel Multi Class based Feature Extraction (MC-FE) method has been proposed for medical data classification. Genomic datasets, or gene expression-based microarray medical datasets, are categorised for cancer diagnosis. The first stage involves applying a feature extraction technique. The Principal Component Analysis (PCA) is used to extract the features for medical data classification to detect leukemia, colon tumors, and prostate cancer. The MPSO (modified particle swarm optimization) technique is used at the second stage to pick features from high-dimensional microarray medical datasets like prostate cancer, leukemia, and colon tumors. Finally, SVM, KNN, and Naive Bayes classifiers are used to classify medical data. Pham, Tin H., and Bijan Raahemi [23] A systematic literature review is conducted on five major digital databases of science and engineering. Results: The primary search included 695 articles. After removing 263 duplicated articles, 432 studies remained to be screened. Among those, 317 irrelevant papers were removed. We then excluded 77 studies according to the exclusion criteria. Finally, 38 articles were selected for this study. Conclusion: Out of 38 studies, 28 papers discussed Swarm-based algorithms, 2 papers studied Genetic Algorithms, and 8 papers covered algorithms in both categories. Considering the application domains, 21 of the articles focused on problems in the healthcare sector, while the rest mainly investigated issues in cybersecurity, text classification, and image processing. Hybridization with other BIAs was employed by approximately 18.5% of papers, and 13 out of 38 studies used S-shaped transfer





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functions. The majority of studies used supervised classification methods such as k-NN and SVM for building fitness functions.

INFORMATION GAIN BASED FEATURE SELECTION METHOD

Information Gain (IG) [24] [25] is a popular feature selection method used primarily in the context of classification problems. It measures the reduction in uncertainty or entropy in the target variable due to the presence of a feature.

Understanding Entropy

Entropy is a measure of the unpredictability or impurity in a dataset. In the context of feature selection, it quantifies the amount of disorder or randomness in the target variable.

For a target variable Y with n possible values, the entropy $H(Y)$ is defined as:

$$H(Y) = - \sum_{i=1}^n P(y_i) \log_2 P(y_i) \quad (1)$$

Where $P(y_i)$ is the probability of occurrence of the i -th value of y .

Conditional Entropy

Conditional entropy quantifies the amount of entropy (uncertainty) in the target variable Y given the presence of another variable X . It is defined as:

$$H(Y|X) = - \sum_{j=1}^m P(x_j) \sum_{i=1}^n P(y_i|x_j) \log_2 P(y_i|x_j) \quad (2)$$

Where $P(x_j)$ is the probability of the j -th value of X , and $P(y_i|x_j)$ is the conditional probability of y_i given x_j .

Information Gain Calculation

Information Gain (IG) is the reduction in entropy of the target variable Y after observing the feature X . It measures how much knowing the feature X reduces the uncertainty about the target variable Y . The IG is calculated as:

$$IG(Y, X) = H(Y) - H(Y|X) \quad (3)$$

Feature Selection using Information Gain

The steps involved in selecting features using Information Gain are as follows:

- **Calculate Entropy of the Target Variable:** Compute the entropy $H(Y)$ of the target variable Y using the formula mentioned above.
- **Calculate Conditional Entropy for each feature:** For each feature X_i in the dataset, calculate the conditional entropy $H(Y|X_i)$ of the target variable given the feature.
- **Compute Information Gain for each feature:** For each feature X_i , compute the $IG(Y, X_i)$ using the formula:

$$IG(Y, X_i) = H(Y) - H(Y|X_i) \quad (4)$$
- **Rank features based on Information Gain:** Rank the features based on their Information Gain values. Features with higher Information Gain are considered more informative and relevant for predicting the target variable.
- **Select Top features:** Select the top k features with the highest IG values as the most relevant features for the model.

RELIEFF BASED FEATURE SELECTION METHOD

The ReliefF algorithm [26] [27] is an extension of the original Relief algorithm and is designed to handle multi-class problems and noisy data. It is a feature weighting method that evaluates the importance of features based on their ability to distinguish between instances that are near each other.

Initialization

Relief F starts by initializing a weight vector W for all features, setting each weight to Zero:

$$W[f_i] = 0 \quad (5)$$

for each feature f_i in the dataset.





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Random Sampling

Relief F iteratively samples instances from the dataset. For each iteration, it randomly selects an instance R from the dataset.

Finding Nearest Neighbors

For the selected instance R, Relief F identifies:

- k nearest neighbors from the same class as R (called “nearest hits”)
- k nearest neighbors from the same class as R (called “nearest hits”)

Updating Feature Weights

Relief F updates the weights of the features based on how well they can distinguish between R and its nearest hits and misses. The update rule for the weight of a feature f is:

$$W[f] = W[f] - \frac{1}{m} \sum_{i=1}^k \left(\frac{|f(R) - f(H_i)|}{k} \right) + \frac{1}{m} \sum_{c \neq \text{class}(R)} \left(\frac{P(c)}{1 - P(\text{class}(R))} \sum_{j=1}^k \left(\frac{|f(R) - f(M_j^c)|}{k} \right) \right) \quad (6)$$

Where $W[f]$ is the weight of feature f , m is the number of iterations, H_i is the i -th nearest hit, M_j^c is the j -th nearest miss from class c , $P(c)$ is the prior probability of class c , $f(R)$ is the value of feature f for instance R. The update increases the weight of a feature if it helps distinguish between instances of different classes (i.e., if the difference between R and nearest misses is large) and decreases the weight if it does not help distinguish between instances of the same class (i.e., if the difference between R and nearest hits is large).

Iteration

Steps 2-4 are repeated for a predefined number of iterations or until convergence. Each iteration refines the weights, improving the ranking of features based on their ability to discriminate between instances of different classes.

Ranking and Selecting Features

After completing the iterations, the features are ranked based on their final weights. Features with higher weights are considered more important and relevant for the classification task. ReliefF is a powerful feature selection method that evaluates feature importance based on their ability to discriminate between instances of different classes, considering local information around each instance. This method is particularly useful for handling multi-class problems and noisy data, providing a robust way to select relevant features that contribute to accurate and efficient predictive modeling.

WHALE OPTIMIZATION ALGORITHM BASED FEATURE SELECTION METHOD

The Whale Optimization Algorithm (WOA) [28] [29] is a nature-inspired metaheuristic optimization algorithm based on the social hunting behavior of humpback whales, specifically their bubble-net feeding strategy. In feature selection, WOA can be employed to find an optimal subset of features that maximizes the performance of a predictive model. Here's a detailed explanation of how the WOA-based feature selection method works:

Stage 1: Initialization

- **Population Initialization:** Initialize a population of whales (solutions), where each whale represents a potential solution (a subset of features). The size of the population is N , and each whale's position in the search space is represented as a binary vector indicating the presence (1) or absence (0) of features.
- **Fitness Function:** Define a fitness function to evaluate the quality of each solution. This function typically measures the predictive accuracy of a machine learning model using the selected features.

Stage 2: Whale Behavior Modeling

WOA mimics two main behaviors of humpback whales: the encircling prey mechanism and the bubble-net attacking method.





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Stage 2.1: Encircling Prey

- Whales perceive the position of the best solution (whale) found so far, updating their positions to move towards this optimal solution.

- Update the position of each whale according to the following equations:

$$\bar{D} = |\bar{C} \cdot \bar{X}^*(t) - \bar{X}(t)| \quad (7)$$

$$\bar{X}(t+1) = \bar{X}^*(t) - \bar{A} \cdot \bar{D} \quad (8)$$

Where $\bar{X}^*(t)$ is the position vector of the best solution, $\bar{X}(t)$ is the position vector of the current whale, \bar{A} and \bar{C} are coefficient vector calculated as:

$$\bar{A} = 2\bar{a} \cdot \bar{r} - \bar{a} \quad (9)$$

$$\bar{C} = 2 \cdot \bar{r} \quad (10)$$

Where \bar{a} decreases linearly from 2 to 0 over the course of iterations, and \bar{r} is a random vector in [0,1].

Stage 2.2: Bubble – Net Attacking Model

This method includes two strategies: shrinking encircling mechanism and spiral updating position.

- Shrinking Encircling Mechanism:** This is controlled by \bar{A} . When $|\bar{A}| < 1$, the whales move towards the best solution.

- Spiral Updating Position:** This models the helix-shaped movement of whales around their prey.

$$\bar{X}(t+1) = \bar{D}' \cdot e^{bl} \cdot \cos(2\pi l) + \bar{X}^*(t) \quad (11)$$

Where $\bar{D}' = |\bar{X}^*(t) - \bar{X}(t)|$, b is a constant defining the spiral shape, and l is the random number in $[-1,1]$. The probability p is used to switch between the shrinking encircling mechanism and the spiral model. Typically, $p = 0.50$.

Stage 3: Exploration Phase

To enhance exploration, whales search for prey randomly based on the positions of other whales. When $|\bar{A}| \geq 1$, the whales move towards random positions in the search space, facilitating exploration.

Stage 4: Fitness Evaluation

Evaluate the fitness of each whale (solution) using the defined fitness function. This step assesses how well the selected subset of features performs in terms of model accuracy.

Stage 5: Updating Best Solution

Identify the whale with the best fitness score. Update the best-known position $\bar{X}^*(t)$ if a better solution is found.

Stage 6: Iteration

Repeat steps 2-5 for a predefined number of iterations or until convergence criteria are met.

Stage 7: Selection of Optimal Feature Subset

After the iterations, the position vector of the best whale represents the optimal subset of features. Features corresponding to 1s in the binary vector are selected for the final model.

PROPOSED TWICE FILTER OPTIMIZATION BASED FEATURE SELECTION (TTO-FS) METHOD

The proposed hybrid TTO-FS method integrates Information Gain (IG), ReliefF, and Whale Optimization Algorithm (WOA) to identify the most relevant features from high-dimensional datasets. The hybrid method is designed to leverage the strengths of each individual technique, thereby enhancing the overall performance and robustness of the feature election process.

Phase 1: Initial Feature Ranking using IG and ReliefF

Step 1: Information Gain (IG) Calculation

- Step 1.1: Compute the Entropy of the target variable:** The entropy $H(Y)$ of the target variable Y is calculated to measure its uncertainty using equation (1).





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- **Step 1.2: Calculate Conditional Entropy for Each Feature:** For each feature X, the conditional entropy $H(Y|X)$ is computed to measure the remaining uncertainty about Y given X using the equation (2).
- **Step 1.3: Calculate Information Gain for Each Feature:** Information Gain (IG) is calculated for each feature to determine how much information about Y is gained by knowing X using equation (3).
- **Step 1.4: Rank Features Based on Information Gain:** Rank the features from highest to lowest based on their IG values. Higher IG values indicate more relevant features.

Step 2: Relief F Calculation

- **Step 2.1: Initialize Weights for All Features:** Initialize a weight vector W for all features using equation (5).
- **Step 2.2: Random Sampling:** For each iteration, randomly select an instance R from the dataset.
- **Step 2.3: Find Nearest Neighbors:** For the selected instance R, identify k nearest hits (same class as R) and k nearest misses (different classes).
- **Step 2.4: Update Weights:** Update the weight of each feature based on its ability to distinguish between R and its nearest hits and misses using equation (6).
- **Step 2.5: Rank Features Based on Weights:** Rank the features from highest to lowest based on their weights. Higher weights indicate more relevant features.

Phase 2: Combined Ranking of Features

Step 3: Normalize Rankings

- **Step 3.1: Normalize IG and ReliefF Rankings:** Normalize the ranks obtained from IG and ReliefF to a common scale (e.g., 0 to 1) to ensure they are comparable.

Step 4: Aggregate Rankings

- **Step 4.1: Combine the Normalized Ranks:** Aggregate the normalized ranks by averaging or using a weighted sum:

$$Rank_{combined}(f_i) = \alpha \cdot Rank_{IG}(f_i) + (1 - \alpha) \cdot Rank_{ReliefF}(f_i) \quad (12)$$

Where α is a weighting factor (e.g., 0.5)

- **Step 4.2: Select Top features:** Select the top k features based on the combined ranking. This subset of features will be used in the next phase.

Phase 3: Refinement Using Whale Optimization Algorithm (WOA)

Step 5: Initialization

- **Step 5.1: Population Initialization:** Initialize a population of whales (solutions), where each whale represents a subset of the top k features. Each whale's position is represented by a binary vector indicating the presence (1) or absence (0) of features.
- **Step 5.2: Fitness Function:** Define a fitness function to evaluate the quality of each subset. This function typically measures the predictive accuracy of a machine learning model using the selected features. For instance, accuracy, precision, recall, or F1-score can be used as metrics.

Step 6: Whale Behavior Modeling

- **Step 6.1: Encircling the prey**
 - Update position of each whale from equation (7) to equation (10).
- **Step 6.2: Bubble-Net Attacking Method**
 - Shrinking Encircling Mechanism: When $|\vec{A}| \geq 1$ whales move towards the best solution.
 - Spiral Updating Position using equation (11).
 - Exploration phase: Random search: When $|\vec{A}| \geq 1$, whales move towards random positions to enhance exploration and avoid local optimal.

Step 7: Fitness Evaluation

- **Step 7.1: Evaluate Fitness of Each Whale:** Use the fitness function to assess the quality of each subset of features. This involves training a machine learning model with the selected features and measuring its performance.





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Step 8: Updating Best Solution

- **Step 8.1: Identify the Best Whale:** Find the whale with the best fitness score in the current population and update the best-known solution $\bar{X} * (t)$ if a better solution is found.

Step 9: Iteration

- **Step 9.1: Repeat the Process:** Repeat the optimization process for a predefined number of iterations or until convergence criteria are met. Each iteration refines the selection of features by updating the whales' positions.

Phase 4: Final Selection of Features

Step 10: Select Optimal Feature Subset

- **Step 10.1: Final Whale Solution:** After the completion of iterations, the position vector of the best whale represents the optimal subset of features. The selected features correspond to the positions with 1s in the binary vector.

RESULT AND DISCUSSION

Dataset Description

In this research work, the three different clinical datasets are considered to evaluate the performance of the Proposed TTO-FS method. Dermatology [30], Lung Cancer [31] and Hepatitis [32] datasets are considered in this work. Table 1 depicts the number of features in the given considered datasets.

Performance Metrics

Table 2 gives the performance metrics used in this research work, to evaluate the performance of the Proposed TTO-FS methods using Classification techniques, Artificial Neural Network (ANN), Random Forest (RF) and Support Vector Machine (SVM). The performance of the Proposed TTO-FS method is evaluated with the existing feature selection techniques like Information Gain (IG), ReliefF(RFF), Whale Optimization Algorithm (WOA), Artificial Bee Colony Optimization (ABO).

Performance Analysis of the Proposed TTO-FS Method for Dermatology Dataset

Table 1 give the number of features obtained by the Proposed TTO-FS method and existing feature selection methods. From the table 1, it is clear that the proposed TTO-FS method gives less number of features than the existing feature selection methods. Table 2 gives the Classification Accuracy (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques. From the table 3.2, Original Dataset: The baseline accuracies without any feature selection are the lowest across all classifiers, ranging from 43.10% (SVM) to 48.32% (ANN). Proposed TTO-FS: This method significantly outperforms all other feature selection techniques, achieving the highest accuracies for SVM (93.55%), RF (94.86%), and ANN (95.06%). WOA: The second-best performing method with accuracies of 71.76% (SVM), 72.30% (RF), and 72.87% (ANN). IG: Performs well with accuracies of 69.63% (SVM), 69.97% (RF), and 70.84% (ANN), slightly better than RFF and ABC. RFF: Moderate performance with accuracies of 66.54% (SVM), 66.86% (RF), and 68.75% (ANN). ABC: Shows lower accuracies compared to IG and WOA but still better than the original dataset, with 65.46% (SVM), 65.77% (RF), and 67.64% (ANN). Table 3 gives the True Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques. From the table 3.3, Original Dataset: The baseline TPRs without any feature selection are the lowest across all classifiers, ranging from 52.61% (SVM) to 52.94% (RF). Proposed TTO-FS: This method achieves the highest TPRs for SVM (93.35%), RF (94.99%), and ANN (94.97%), significantly outperforming all other feature selection techniques. WOA: The second-best performing method with TPRs of 75.37% (SVM), 76.37% (RF), and 70.54% (ANN). IG: Performs well with TPRs of 76.07% (SVM), 74.59% (RF), and 71.35% (ANN), slightly better than WOA for SVM. RFF: Moderate performance with TPRs of 69.18% (SVM), 67.68% (RF), and 65.45% (ANN). ABC: Shows lower TPRs compared to IG and WOA but still better than the original dataset, with 64.34% (SVM), 66.57% (RF), and 68.29% (ANN). Table 4 gives the False Positive Rate (in %) obtained by the Proposed



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and Existing Feature Selection methods using ANN, RF and SVM classification techniques. From the table 3.4, Original Dataset: The baseline FPRs without any feature selection are the highest across all classifiers, ranging from 56.83% (ANN) to 67.17% (SVM). Proposed TTO-FS: This method achieves the lowest FPRs for SVM (6.21%), RF (5.26%), and ANN (4.84%), significantly outperforming all other feature selection techniques. WOA: The second-best performing method with FPRs of 32.18% (SVM), 32.80% (RF), and 24.22% (ANN). IG: Performs well with FPRs of 35.62% (SVM), 34.77% (RF), and 29.73% (ANN), slightly higher than WOA. RFF: Moderate performance with FPRs of 46.53% (SVM), 45.66% (RF), and 40.82% (ANN). ABC: Shows higher FPRs compared to IG and WOA but still lower than the original dataset, with 47.42% (SVM), 46.75% (RF), and 41.71% (ANN). Table 5 gives the Precision (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques. From the table 3.5, Original Dataset: The baseline precision without any feature selection is the lowest across all classifiers, ranging from 45.81% (SVM) to 51.72% (ANN). Proposed TTO-FS: This method achieves the highest precision for SVM (94.30%), RF (95.16%), and ANN (95.50%), significantly outperforming all other feature selection techniques. WOA: The second-best performing method with precision values of 71.97% (SVM), 71.45% (RF), and 78.97% (ANN). IG: Performs well with precision values of 68.79% (SVM), 68.81% (RF), and 73.60% (ANN), slightly lower than WOA. RFF: Moderate performance with precision values of 59.68% (SVM), 59.72% (RF), and 62.51% (ANN). ABC: Shows lower precision compared to IG and WOA but still higher than the original dataset, with 58.57% (SVM), 58.61% (RF), and 61.43% (ANN). Table 6 gives the Miss Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques. From the table 3.6, Original Dataset: The baseline miss rates without any feature selection are the highest across all classifiers, ranging from 47.06% (RF) to 47.39% (SVM). Proposed TTO-FS: This method achieves the lowest miss rates for SVM (6.65%), RF (5.01%), and ANN (5.03%), significantly outperforming all other feature selection techniques. WOA: The second-best performing method with miss rates of 24.63% (SVM), 23.63% (RF), and 29.46% (ANN). IG: Performs well with miss rates of 23.93% (SVM), 25.41% (RF), and 28.65% (ANN), slightly higher than WOA. RFF: Moderate performance with miss rates of 32.82% (SVM), 36.52% (RF), and 39.76% (ANN). ABC: Shows higher miss rates compared to IG and WOA but still lower than the original dataset, with 33.91% (SVM), 37.61% (RF), and 40.85% (ANN). Table 7 gives the Specificity (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques. From the table 3.7, Original Dataset: The baseline specificity without any feature selection is the lowest across all classifiers, ranging from 32.83% (SVM) to 43.17% (ANN). Proposed TTO-FS: This method achieves the highest specificity for SVM (93.79%), RF (94.74%), and ANN (95.16%), significantly outperforming all other feature selection techniques. WOA: The second-best performing method with specificity values of 67.82% (SVM), 67.20% (RF), and 75.78% (ANN). IG: Performs well with specificity values of 64.38% (SVM), 65.23% (RF), and 70.27% (ANN), slightly lower than WOA. RFF: Moderate performance with specificity values of 53.49% (SVM), 54.32% (RF), and 59.38% (ANN). ABC: Shows lower specificity compared to IG and WOA but still higher than the original dataset, with 52.38% (SVM), 53.21% (RF), and 58.24% (ANN).

Performance Analysis of the Proposed TTO-FS Method for Lung Cancer Dataset

Table 8 give the number of features obtained by the Proposed TTO-FS method and existing feature selection methods. From the table 4.1, it is clear that the proposed TTO-FS method gives less number of features than the existing feature selection methods. Table 9 gives the Classification Accuracy (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset. From the table 4.2, Original Dataset: The baseline accuracies without any feature selection are the lowest across all classifiers, ranging from 43.97% (SVM) to 48.32% (ANN). Proposed TTO-FS: This method achieves the highest classification accuracies for SVM (93.46%), RF (94.09%), and ANN (94.91%), significantly outperforming all other feature selection techniques. WOA: The second-best performing method with accuracies of 71.67% (SVM), 71.47% (RF), and 72.59% (ANN). IG: Performs well with accuracies of 69.34% (SVM), 70.94% (RF), and 70.84% (ANN), slightly lower than WOA. RFF: Moderate performance with accuracies of 58.43% (SVM), 59.85% (RF), and 59.73% (ANN). ABC: Shows lower accuracies compared to IG and WOA but still higher than the original dataset, with 57.34% (SVM), 58.74% (RF), and 58.64% (ANN). Table 10 gives the True Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset. From the table 4.3, Original Dataset: The baseline TPRs without any feature selection are varied across



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classifiers, ranging from 47.68% (RF) to 52.76% (ANN). Proposed TTO-FS: This method achieves the highest TPRs for SVM (92.42%), RF (94.51%), and ANN (95.51%), significantly outperforming all other feature selection techniques. IG: Performs well with TPRs of 73.05% (SVM), 75.50% (RF), and 74.45% (ANN), slightly lower than the proposed TTO-FS method. WOA: Shows strong performance with TPRs of 82.30% (SVM), 74.90% (RF), and 71.19% (ANN). RFF: Moderate performance with TPRs of 62.16% (SVM), 64.41% (RF), and 63.34% (ANN). ABC: Shows lower TPRs compared to IG and WOA but still higher than the original dataset, with 61.27% (SVM), 63.32% (RF), and 62.25% (ANN).

Table 11 gives the False Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset. From the table 4.4, Original Dataset: The baseline FPRs without any feature selection are relatively high across classifiers, ranging from 56.58% (ANN) to 63.80% (SVM). Proposed TTO-FS: This method achieves the lowest FPRs for SVM (5.36%), RF (6.36%), and ANN (5.72%), significantly outperforming all other feature selection techniques. WOA: The second-best performing method with FPRs of 31.91% (SVM), 32.31% (RF), and 25.60% (ANN). IG: Performs well with FPRs of 35.31% (SVM), 33.75% (RF), and 32.87% (ANN), slightly higher than WOA. RFF: Moderate performance with FPRs of 44.42% (SVM), 42.84% (RF), and 43.78% (ANN). ABC: Shows higher FPRs compared to IG and WOA but still lower than the original dataset, with 45.53% (SVM), 43.75% (RF), and 44.69% (ANN). Table 12 gives the Precision (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset. From the table 4.5, Original Dataset: The baseline precision without any feature selection varies across classifiers, ranging from 46.11% (SVM) to 52.34% (RF). Proposed TTO-FS: This method achieves the highest precision for SVM (95.11%), RF (94.16%), and ANN (94.17%), significantly outperforming all other feature selection techniques. WOA: The second-best performing method with precision values of 72.76% (SVM), 71.92% (RF), and 78.18% (ANN). IG: Performs well with precision values of 69.21% (SVM), 69.77% (RF), and 70.04% (ANN), slightly lower than WOA. RFF: Moderate performance with precision values of 58.32% (SVM), 58.68% (RF), and 61.13% (ANN). ABC: Shows lower precision compared to IG and WOA but still higher than the original dataset, with 57.43% (SVM), 57.79% (RF), and 60.24% (ANN). Table 13 gives the Miss Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset. From the table 4.6, Original Dataset: The baseline miss rates without any feature selection are varied across classifiers, ranging from 47.24% (ANN) to 52.32% (RF). Proposed TTO-FS: This method achieves the lowest miss rates for SVM (7.58%), RF (5.49%), and ANN (4.49%), significantly outperforming all other feature selection techniques. WOA: The second-best performing method with miss rates of 17.70% (SVM), 25.10% (RF), and 28.81% (ANN). IG: Performs well with miss rates of 29.65% (SVM), 24.50% (RF), and 25.55% (ANN), slightly higher than TTO-FS. RFF: Moderate performance with miss rates of 38.54% (SVM), 35.56% (RF), and 36.67% (ANN). ABC: Shows higher miss rates compared to IG and WOA but still lower than the original dataset, with 39.45% (SVM), 36.67% (RF), and 37.78% (ANN). Table 14 gives the Specificity (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset. From the table 4.7, Original Dataset: The baseline specificities without any feature selection are relatively low across classifiers, ranging from 36.20% (SVM) to 43.42% (ANN). Proposed TTO-FS: This method achieves the highest specificities for SVM (94.64%), RF (93.64%), and ANN (94.28%), significantly outperforming all other feature selection techniques. WOA: The second-best performing method with specificities of 68.09% (SVM), 67.69% (RF), and 74.40% (ANN). Information Gain (IG): Performs well with specificities of 64.91% (SVM), 66.25% (RF), and 67.13% (ANN), slightly lower than TTO-FS. RFF: Moderate performance with specificities of 55.82% (SVM), 55.34% (RF), and 56.24% (ANN). ABC: Shows lower specificities compared to IG and WOA but still higher than the original dataset, with 54.71% (SVM), 54.45% (RF), and 55.35% (ANN).

Performance Analysis of the Proposed TTO-FS Method for Hepatitis Dataset

Table 15 give the number of features obtained by the Proposed TTO-FS method and existing feature selection methods. From the table 5.1, it is clear that the proposed TTO-FS method gives less number of features than the existing feature selection methods. Table 16 gives the Classification Accuracy (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset. From the



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table 5.2, Original Dataset: The baseline accuracies without any feature selection are varied across classifiers, ranging from 44.93% (SVM) to 50.16% (ANN). Proposed TTO-FS: This method achieves the highest classification accuracies for SVM (95.15%), RF (95.85%), and ANN (95.15%), significantly outperforming all other feature selection techniques. WOA: Shows strong performance with accuracies of 74.04% (SVM and ANN) and 72.20% (RF). IG: Performs well with accuracies of 68.81% (SVM), 67.11% (RF), and 66.19% (ANN), slightly lower than the proposed TTO-FS method. RFF: Moderate performance with accuracies of 57.92% (SVM), 58.22% (RF), and 55.28% (ANN). ABC: Shows lower accuracies compared to IG and WOA but still higher than the original dataset, with 56.81% (SVM), 57.32% (RF), and 54.19% (ANN). Table 17 gives the True Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset. From the table 5.3, Original Dataset: The baseline true positive rates without any feature selection vary across classifiers, ranging from 49.44% (RF) to 55.11% (SVM). Proposed TTO-FS: This method achieves the highest true positive rates for SVM (96.53%), RF (96.90%), and ANN (95.02%), significantly outperforming all other feature selection techniques. WOA: Shows strong performance with true positive rates of 84.55% (SVM), 80.57% (RF), and 81.74% (ANN). IG: Performs well with true positive rates of 67.35% (SVM), 69.42% (RF), and 70.57% (ANN), slightly lower than the proposed TTO-FS method. RFF: Moderate performance with true positive rates of 56.43% (SVM), 58.31% (RF), and 60.46% (ANN). ABC: Shows lower true positive rates compared to IG and WOA but still higher than the original dataset, with 55.65% (SVM), 57.53% (RF), and 59.68% (ANN).

Table 18 gives the False Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset. From the table 5.4, Original Dataset: The baseline false positive rates without any feature selection vary significantly across classifiers, ranging from 54.40% (ANN) to 64.74% (SVM). Proposed TTO-FS: This method achieves the lowest false positive rates for SVM (6.32%), RF (5.305%), and ANN (4.704%), significantly outperforming all other feature selection techniques. WOA: Shows strong performance with false positive rates of 35.76% (SVM), 36.21% (RF), and 34.56% (ANN). IG: Performs well with false positive rates of 28.79% (SVM), 35.32% (RF), and 38.08% (ANN), notably higher than TTO-FS. RFF: Moderate performance with false positive rates of 37.88% (SVM), 36.43% (RF), and 39.19% (ANN). ABC: Shows slightly higher false positive rates compared to WOA but generally lower than the original dataset, with 38.06% (SVM), 37.65% (RF), and 40.32% (ANN). Table 19 gives the Precision (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset. Original Dataset: The baseline precisions without any feature selection are varied across classifiers, ranging from 44.75% (SVM) to 52.80% (RF). Proposed TTO-FS: This method achieves the highest precision scores for SVM (94.24%), RF (95.11%), and ANN (95.56%), significantly outperforming all other feature selection techniques. WOA: Shows strong performance with precision scores of 68.81% (SVM), 69.09% (RF), and 72.55% (ANN). IG: Performs well with precision scores of 74.80% (SVM), 67.58% (RF), and 64.97% (ANN), slightly lower than the proposed TTO-FS method. RFF: Moderate performance with precision scores of 63.91% (SVM), 57.47% (RF), and 53.86% (ANN). ABC: Shows lower precision scores compared to IG and WOA but still higher than the original dataset, with 61.13% (SVM), 56.69% (RF), and 52.08% (ANN). Table 20 gives the Miss Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset. From the table 5.6, Original Dataset: The baseline miss rates without any feature selection vary across classifiers, ranging from 44.89% (SVM) to 50.56% (RF). Proposed TTO-FS: This method achieves the lowest miss rates for SVM (3.47%), RF (3.10%), and ANN (4.98%), significantly outperforming all other feature selection techniques. WOA: Shows strong performance with miss rates of 15.45% (SVM), 19.43% (RF), and 18.26% (ANN). IG: Performs well with miss rates of 32.65% (SVM), 30.58% (RF), and 29.43% (ANN), notably higher than the proposed TTO-FS method. RFF: Moderate performance with miss rates of 41.57% (SVM), 41.69% (RF), and 39.42% (ANN). ABC: Shows higher miss rates compared to IG and WOA but generally lower than the original dataset, with 42.79% (SVM), 42.81% (RF), and 40.64% (ANN). Table 21 gives the Specificity (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset. From the table 5.7, Original Dataset: The baseline specificity scores without any feature selection are varied across classifiers, ranging from 35.26% (SVM) to 45.6% (ANN). Proposed TTO-FS: This method achieves the highest specificity scores for SVM (93.68%), RF (94.70%), and ANN (95.29%), significantly outperforming all other feature selection techniques. WOA: Shows strong performance with specificity





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scores of 64.24% (SVM), 63.79% (RF), and 65.44% (ANN).IG: Performs well with specificity scores of 71.21% (SVM), 64.68% (RF), and 61.92% (ANN), higher than the proposed TTO-FS method.RFF: Moderate performance with specificity scores of 60.12% (SVM), 55.79% (RF), and 50.81% (ANN).ABC: Shows lower specificity scores compared to IG and WOA but generally higher than the original dataset, with 59.35% (SVM), 56.91% (RF), and 49.05% (ANN).

CONCLUSION

The proposed hybrid feature selection method, which combines Information Gain (IG), ReliefF, and Whale Optimization Algorithm (WOA), represents a robust approach to address the challenges posed by high-dimensional datasets in various domains, including clinical research. By integrating Information Gain and ReliefF, the method effectively identifies features that provide the most relevant information for predicting the target variable. Information Gain assesses the individual predictive power of each feature based on its ability to reduce uncertainty about the target variable, while ReliefF evaluates features based on their ability to distinguish between instances of different classes, thus capturing complementary aspects of feature relevance. The inclusion of Whale Optimization Algorithm (WOA) enhances the feature selection process by optimizing the subset of features identified by Information Gain and ReliefF. WOA simulates the social behavior of humpback whales, enabling efficient exploration of the feature space to find subsets that maximize the performance metrics defined by the fitness function. The hybridization of IG, ReliefF, and WOA leverages their respective strengths in feature evaluation and optimization. Information Gain and ReliefF provide a solid foundation for initial feature ranking and selection, while WOA further refines this selection by iteratively improving the subset of features based on the defined fitness criteria. From the results obtained, it is clear that the proposed TTO-FS method with ANN performs better for the considered three clinical datasets.

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Table 1: Number of features in the considered datasets

Name of the Dataset	Number of Features present
Dermatology	35
Lung cancer	57
Hepatitis	20

Table 2: Performance Metrics

Metrics	Equation
Accuracy	$\frac{TP + TN}{TP + FN + TN + FP}$
True Positive Rate (TPR) (Sensitivity or Recall)	$\frac{TP}{TP + FN}$
False Positive Rate (FPR)	$\frac{FP}{FP + TN}$
Precision	$\frac{TP}{TP + FP}$
Specificity	1- False Positive Rate (FPR)
Miss Rate	1-True Positive Rate (TPR)
False Discovery Rate	1- Precision

Table 3: Number of Features obtained by the Proposed and Existing Feature Selection methods for Dermatology Dataset

Feature Selection Techniques	Number of Features present
Original Dataset	35
Information Gain	28
ReliefF	27
Artificial Bee Colony	34
Whale Optimization Algorithm	29
Proposed TTO-FS Method	22





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Table 4: Classification Accuracy (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Dermatology dataset

Feature selection Methods	Classification Accuracy (in %)		
	SVM	RF	ANN
Original Dataset	43.099	46.44	48.32
IG	69.63	69.97	70.84
RFF	66.54	66.86	68.75
ABC	65.46	65.77	67.64
WOA	71.76	72.30	72.87
Proposed TTO-FS	93.55	94.86	95.06

Table 5: True Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Dermatology dataset

Feature selection Methods	True Positive Rate (in %)		
	SVM	RF	ANN
Original Dataset	52.61	52.94	52.80
IG	76.07	74.59	71.35
RFF	69.18	67.68	65.45
ABC	64.34	66.57	68.29
WOA	75.37	76.37	70.54
Proposed TTO-FS	93.35	94.99	94.97

Table 6: False Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Dermatology dataset

Feature selection Methods	False Positive Rate (in %)		
	SVM	RF	ANN
Original Dataset	67.17	61.08	56.83
IG	35.62	34.77	29.73
RFF	46.53	45.66	40.82
ABC	47.42	46.75	41.71
WOA	32.18	32.8	24.22
Proposed TTO-FS	6.21	5.26	4.84

Table 7: Precision (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Dermatology dataset

Feature selection Methods	Precision (in %)		
	SVM	RF	ANN
Original Dataset	45.81	49.01	51.72
IG	68.79	68.81	73.60
RFF	59.68	59.72	62.51
ABC	58.57	58.61	61.43
WOA	71.97	71.45	78.97
Proposed TTO-FS	94.30	95.16	95.50





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Table 8: Miss Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Dermatology dataset

Feature selection Methods	Miss Rate (in %)		
	SVM	RF	ANN
Original Dataset	47.39	47.06	47.2
IG	23.93	25.41	28.65
RFF	32.82	36.52	39.76
ABC	33.91	37.61	40.85
WOA	24.63	23.63	29.46
Proposed TTO-FS	6.65	5.01	5.03

Table 9: Specificity (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Dermatology dataset

Feature selection Methods	Specificity(in %)		
	SVM	RF	ANN
Original Dataset	32.83	38.92	43.17
IG	64.38	65.23	70.27
RFF	53.49	54.32	59.38
ABC	52.38	53.21	58.24
WOA	67.82	67.2	75.78
Proposed TTO-FS	93.79	94.74	95.16

Table 10: Number of Features obtained by the Proposed and Existing Feature Selection methods for Lung Cancer Dataset

Feature Selection Techniques	Number of Features present
Original Dataset	57
Information Gain	48
ReliefF	46
Artificial Bee Colony	51
Whale Optimization Algorithm	45
Proposed TTO-FS Method	41

Table 11: Classification Accuracy (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset

Feature selection Methods	Classification Accuracy (in %)		
	SVM	RF	ANN
Original Dataset	43.97	44.98	48.32
IG	69.34	70.94	70.84
RFF	58.43	59.85	59.73
ABC	57.34	58.74	58.64
WOA	71.67	71.47	72.59
Proposed TTO-FS	93.46	94.09	94.91





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Table 12: True Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset

Feature selection Methods	True Positive Rate (in %)		
	SVM	RF	ANN
Original Dataset	51.26	47.68	52.76
IG	73.05	75.50	74.45
RFF	62.16	64.41	63.34
ABC	61.27	63.32	62.25
WOA	82.3	74.90	71.19
Proposed TTO-FS	92.42	94.51	95.51

Table 13: False Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset

Feature selection Methods	False Positive Rate (in %)		
	SVM	RF	ANN
Original Dataset	63.8	57.67	56.58
IG	35.31	33.75	32.87
RFF	44.42	42.84	43.78
ABC	45.53	43.75	44.69
WOA	31.91	32.31	25.60
Proposed TTO-FS	5.36	6.36	5.72

Table 14: Precision (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset

Feature selection Methods	Precision (in %)		
	SVM	RF	ANN
Original Dataset	46.11	52.34	50.84
IG	69.21	69.77	70.04
RFF	58.32	58.68	61.13
ABC	57.43	57.79	60.24
WOA	72.76	71.92	78.18
Proposed TTO-FS	95.11	94.16	94.17

Table 15: Miss Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset

Feature selection Methods	Miss Rate (in %)		
	SVM	RF	ANN
Original Dataset	48.74	52.32	47.24
IG	29.65	24.5	25.55
RFF	38.54	35.56	36.67
ABC	39.45	36.67	37.78
WOA	17.7	25.1	28.81
Proposed TTO-FS	7.58	5.49	4.49





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Table 16: Specificity (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Lung Cancer dataset

Feature selection Methods	Specificity(in %)		
	SVM	RF	ANN
Original Dataset	36.2	42.33	43.42
IG	64.91	66.25	67.13
RFF	55.82	55.34	56.24
ABC	54.71	54.45	55.35
WOA	68.09	67.69	74.4
Proposed TTO-FS	94.64	93.64	94.28

Table 17: Number of Features obtained by the Proposed and Existing Feature Selection methods for Hepatitis Dataset

Feature Selection Techniques	Number of Features present
Original Dataset	20
Information Gain	14
ReliefF	15
Artificial Bee Colony	18
Whale Optimization Algorithm	14
Proposed TTO-FS Method	12

Table 18: Classification Accuracy (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset

Feature selection Methods	Classification Accuracy (in %)		
	SVM	RF	ANN
Original Dataset	44.93	45.81	50.16
IG	68.81	67.11	66.19
RFF	57.92	58.22	55.28
ABC	56.81	57.32	54.19
WOA	74.04	72.20	74.04
Proposed TTO-FS	95.15	95.85	95.15

Table 19: True Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset

Feature selection Methods	True Positive Rate (in %)		
	SVM	RF	ANN
Original Dataset	55.11	49.44	54.26
IG	67.35	69.42	70.57
RFF	56.43	58.31	60.46
ABC	55.65	57.53	59.68
WOA	84.55	80.57	81.74
Proposed TTO-FS	96.53	96.90	95.02





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Table 20: False Positive Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset

Feature selection Methods	False Positive Rate (in %)		
	SVM	RF	ANN
Original Dataset	64.74	59.04	54.40
IG	28.79	35.32	38.08
RFF	37.88	36.43	39.19
ABC	38.06	37.65	40.32
WOA	35.76	36.21	34.56
Proposed TTO-FS	6.32	5.305	4.704

Table 21: Precision (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset

Feature selection Methods	Precision (in %)		
	SVM	RF	ANN
Original Dataset	44.75	52.80	52.67
IG	74.80	67.58	64.97
RFF	63.91	57.47	53.86
ABC	61.13	56.69	52.08
WOA	68.81	69.09	72.55
Proposed TTO-FS	94.24	95.11	95.56

Table 22: Miss Rate (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset

Feature selection Methods	Miss Rate (in %)		
	SVM	RF	ANN
Original Dataset	44.89	50.56	45.74
IG	32.65	30.58	29.43
RFF	41.57	41.69	39.42
ABC	42.79	42.81	40.64
WOA	15.45	19.43	18.26
Proposed TTO-FS	3.47	3.10	4.98

Table 23: Specificity (in %) obtained by the Proposed and Existing Feature Selection methods using ANN, RF and SVM classification techniques for Hepatitis dataset

Feature selection Methods	Specificity (in %)		
	SVM	RF	ANN
Original Dataset	35.26	40.96	45.6
IG	71.21	64.68	61.92
RFF	60.12	55.79	50.81
ABC	59.35	56.91	49.05
WOA	64.24	63.79	65.44
Proposed TTO-FS	93.68	94.70	95.29





Analysis of Time-Based Public Transport Demand Prediction Using OPTUNA Framework

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ABSTRACT

Buses are the most popular and easy mode of transportation in all over the world. The state government operates bus service in all routes with low-cost fare. Traffic congestion has risen at an alarming rate due to an increase in the number of automobiles. Travel time have increased as a result, while accessibility and mobility have worsened. The primary challenge encountered by passengers is the absence of information regarding bus numbers that are accessible on a certain route and the approximate time of bus departure. The delay in bus operations, could have several reasons which are inclement weather, traffic jam, and breakdowns. Neither the arrival time of the bus nor the delay are known to the people waiting at the bus stop. In order to address this problem, encouraging the usage of public transportation seems to be a feasible way. Over the past ten years, prediction of bus arrival time has become a fascinating subject around the world. In the transportation sector, Machine Learning (ML) technologies have already shown great promise and have additionally shown to yield a larger return on investment than traditional methods. In this research work , authors propose and develop predictive models to predict public transport demand for passenger transit based on bus arrival time. The dataset shows the proportion of buses operated by the Rochester-Genesee Regional Transportation Authority (RGRTA) that arrive on time. Initially, lazy predict classifier is used for solving regression-based dataset for predicting the bus demand in On-time based passenger transit. Based on the examination of lazy classifiers, the Decision Tree Regressor (DTR) has been identified as the best model. It is assessed using the most advanced hyperparameter optimization framework (OPTUNA). The proposed OPTUNA based DTR which is utilized to identify On-time performance of bus services-based passenger transit. Using OPTUNA for



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search is an efficient and beneficial approach considering the search speed and the improvement in model accuracy. According to the experimental data, the proposed approach performs better where the R-squared score is 0.9878 with best hyperparameter to be optimized.

Keywords: Buses, public transport, prediction, demand, hyperparameter, optimization, OPTUNA, Lazy Predict

INTRODUCTION

Traffic congestion has become a worldwide phenomenon and has grown at a rapid pace in recent years. The increase in population growth, motorization and urbanisation are blamed for this spike. Congestion damages the transportation network, lengthens travel time, emits more emissions and fuel also decreases travelling and easy access. Building more roads, highways, separate lanes, and other transportation infrastructure can help to mitigate this problem by increasing its capacity. Due to its own drawbacks, this option is not practical. Despite being the most popular mode of transportation, travellers are unaware of details like arrival time, precise routes, and buses that are available along the way. It is expected of passengers to remain immobile for an endless period of time without being informed regarding the bus where the people are waiting for or any other information about it. The challenging task for managing bus services are due to lack of information about route, location and traffic. In order to tackle the issues encountered by policy makers and bus managers, Intelligent Transportation System (ITS) has been suggested [1]. Without building new infrastructure, the goal of these transport services and technologies is to improve the effectiveness, safety, dependability, and environmental sustainability of existing transport networks. Promoting public transport to make it more desirable than private vehicles is a key component of ITS. From the viewpoint of the passenger, one of the most crucial markers of a dependable and appealing bus service is the provision of accurate journey and schedules for arrival [2]. A new age in transportation engineering and quality control has been brought about by the integration of growing technologies in public transportation, such as real-time tracking systems and new automatic data collecting. The challenge at hand is carrying out an extensive investigation to comprehend and measure the impact of punctuality on bus passengers. On-time performance refers to the ability of bus services to adhere to their published schedules, arriving and departing from stops as planned.

In the transportation sector, ML technologies have already shown great promise and have even shown to yield a larger return on investment than traditional methods. Still, there is room for improvement in the use and exploitation of ML techniques in transportation-related problems. The fundamental objectives of these solutions are to lessen traffic, enhance security and reduce human mistake, limit adverse environmental effects, optimum energy efficiency, and raise surface transportation productivity and efficiency. In feature engineering, data analytics can be enhanced by the capability of ML models and it transforms the unstructured data into features so that important information in the data can be highlighted. The prediction power of computational approaches can be increased while streamlining and accelerating data transformations by feature engineering to choose pertinent features or create unique features for both supervised and unsupervised learning. ML-based model might help bridge the gap between passengers and transport service. This research work has suggested a Lazy Predict (LP) model, which is simple and straightforward for anyone who is familiar with scikit-learn. In this study to provide prediction for create a Lazy Classifier (LC) instance which will get predictions from all of the models for each and every observation. The framework must fit the data for each model, then use metrics to determine which model has the highest accuracy for the current dataset, and finally pick the optimal model. The effectiveness of any classification algorithm is largely dependent on its ideal hyperparameters [3, 4]. The best set of hyperparameters can be chosen to increase the classification algorithm's accuracy.

To determine the ideal hyperparameter values for the ML model, an advanced hyperparameter optimisation framework (OPTUNA) [5] was used in this investigation. As a result, among the available hyperparameters, the best



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appropriate set was chosen for this investigation. There are several ways to achieve hyperparametric optimisation, including grid and random searches. The OPTUNA hyperparametric search is an additional technique. Conventional random and grid search methods waste a lot of time and are inefficient since they do not learn from the previous optimisation, which is mostly dependent on the amount of hyperparameters in the ML.As needed, the OPTUNA framework modifies the hyperparameters based on ongoing learning from prior optimisations. Consequently, OPTUNA was selected for hyperparameter optimisation in the present research.

The following is a list of this manuscript's primary contributions.

- First, the percentage of buses that depart from their starting point or reach their destination is included in a data collecting module that gathers information on on-time performance.
- To acquire data from open-source data repository and pre-process it using python libraries.
- To build ML models for the classification problem, and train them with the pre-processed dataset.
- To evaluate ML models based on various accuracy metrics to get the best fit model using LP classifier.
- To optimize the hyperparameters using optimization techniques/algorithms to fine tune the model.
- To compare the chosen models and finalize on the robust classification model to accurately predict the demand of bus required for a given period of time based on passenger transit.

LITERATURE REVIEW

A real-time bus management system that considers a variety of aspects, such as traffic congestion and the environment, is described by Shanthi *et al.* [6]. Passengers receive notification of the estimated bus arrival time at their endpoint through an HCI-based website and a mobile app. There are few factors such as weather and the flow of traffic in the bus's present location are utilised for the ETA prediction employing the Support Vector Regression technique. When tested, the model displayed an RMSE of 27 seconds. The goal of the Hossein Moosavi *et al.* [7] describes to identify the optimal tree-based ML algorithm and route creation approach for bus journey time prediction for high- and a low-frequency bus route. Furthermore, the precise, dependable, and useful "key stop-based" route creation method was first presented in this study. In the work by Faruk Serin *et al.* [8] discusses bus arrival time was predicted using ML techniques with a three-layer architecture. The data used in the case study came from Istanbul's public transport system, and it was processed using both classic and three-layer architecture to apply a variety of ML techniques. According to the experimental findings, the three-layer architecture produced effective outcomes with a MAPE of roughly 2.552. A model to simulate the actions of buses and forecast their delays is attempted to be built, as described by Palys *et al.* [9].

Shrivathsa *et al* [10] predicting travel time of bus from historical data is proposed using Artificial Neural Network (ANN). By analysing the data, calculate the time taken to reach the destination for every trip and every day. A new ANN method proves that, it is accurate and speed to predict the travel time. The public transportation system's success or failure is largely dependent on its dependability. The predicting issue for transport travel systems was proposed by Dan Luo, Dong Zhao, *et al.* [11] discusses about bus transit system and passenger flow prediction using Deep Learning (DL). The real-time application proposed by Nagaraj *et al.* [12] aids in the detection of traveller movement at a separate site. Several elements in the dataset are taken into account for forecasting, including bus type, bus id, source, destination, number of passengers, slot number and income. After the parameters are processed and the clustered data is divided into regions and sent to the deep learning model for prediction. Next, the clustered data is moved to a Long Short-Term Memory (LSTM) model, which eliminates redundant data from the obtained data. Predicting bus passengers is made more accurate by these systems. To improve the precision of forecasting the demand for bike sharing, Yang *et al.* [13] discusses the several parameters where the suggested model has the potential to significantly increase forecast accuracy. Additionally, this paper examines the impact of various parameters on the predictions made by the model at different times. Bidirectional LSTM (Bi-LSTM) networks were employed by Collini *et al.* [14] to calculate the quantity of bikes and open bike slots at bike-sharing stations. Mehdizadeh Dastjerdi and Morency initially identified six communities in the bike-sharing network, and then this





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paper discusses about CNN-LSTM for predicting the demand for pickups in each neighbourhood [15]. The flow of passenger anticipating based on the UBTS was examined by Archana *et al.* [16]. Here, UBTS concerns are discussed, including prediction of delays, driver conduct, passenger flow, passenger comfort perception fleet size, vehicle failures and sound level. The strategies and solutions for urban transport have offered to address these problems are evaluated. In order to retain a respectable level of service across the whole bus network, Xubin Zhai and Yu Shen [17] discusses low-demand bus services are less likely to be disrupted by real-time cross-line bus dispatching that utilizes scarce vehicle resources, where the proposed model achieves 5% MAPE. The bus-passenger-flow data has erratic features, which Yulong Pei [18] addresses by WPD to break them down into smoother components. The Bi-LSTM model improves the model's capacity for analysing the passenger flow pattern due to the periodicity and nonlinearity of the passenger-flow data. A model for predicting traffic flow based on sparse regression was presented by Zheng *et al.* [19]. Extreme gradient boosting (XGBoost), was employed by Sun *et al.* [20] and Lu *et al.* [21] to predict the level of traffic on the highway. A DL model was developed by Chen *et al.* [22] for prediction of traffic flow in metropolitan road networks.

Dataset Description

Based on passenger travel, this statistic determines the proportion of RGRTA buses that arrive on time. The percentage of buses that depart from their starting point or reach their destination between 2:59 and 5:59 minutes early is known as the on-time performance. This dataset includes subsidiary, month, year, percent On-time and ridership. The total number of passengers, riders, or boardings is referred to as ridership. It contains a total of 1178 records, and it has 5 attributes described in figure 1.

Data Pre Processing

Along with data collection, a missing value check is performed, and the result is an imputed missing value. The dataset can be transformed to float values because the data cannot be strings. After missing imputation, the data is pre-processed using Robust scaler and label encoder to handle scaling the all-variable unit as unique. Scikit-Learn offers the Label Encoder class for this reason, which allows you to convert all string values to float values. It provides a unique numerical value for every category in a variable, making it easier for ML algorithms to examine and comprehend the data. After removing the median, RobustScaler scales the data using the quantile range. Figure 2 displays the pre-processed data. As a consequence, as shown in Figure 3, a heatmap is constructed utilizing a few data points from the dataset.

RESEARCH METHODOLOGY

The performance of predictive support through data analysis and assist in providing prediction status to the user by proposed method which focus in identifying the best feature fits related to transportation demand. However, one critical factor that significantly influences the attractiveness of bus services to passengers is their on-time performance. The challenge at hand is carrying out an extensive investigation to comprehend and measure the impact of reliability on bus riders. This research work proposed OPTUNA framework has cogitates the best methodical approach due to it tuning parameters like learning rate, loss functions, etc. The Python language is used to develop and train this mode with the help of several libraries, including Matplotlib, NumPy, Scikit-Learn, and Pandas. After being cleaned, the real-time database's data is exported as a CSV file. The functions needed to carry out the hyperparameter optimizations are provided using Scikit-Learn module. The overall proposed model is as shown in figure.4

This study employs an ML classifier model that is created by grouping different classifiers into a single supervised LP library. The dataset is split in term of models and predictions with respect to train dataset and test dataset. The classification models are made to be evaluated using LP supervised LazyRegressor library. LC provides a convenient and efficient way to fit and evaluate multiple ML models, simplifying the model selection process and allowing to focus on building the best model for our data. LP aids in the development of multiple, distinct, fundamental



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ML models using specific code and helps identify which models may perform more accurately avoiding the need for parameter tuning. In this study, regression-based datasets are solved using a lazy regressor in classifying the problem with better prediction of demand in bus transportation required for a given period of time from dataset. In order to employing the best readily accessible ML model, the LP classifier can be optimized for accuracy. This can be achieved by optimizing the top model's hyperparameters, as suggested by the OPTUNA hyperparameter tuning. This research work DecisionTree (DT) Regressor, LGBMRegressor and KNeighbors(KN)Regressor has chosen the best fit model to predict the On-time performance of bus services. Further, this DT regressor of untuned model has chosen best fit models based on predicted value which can be improved using OPTUNA framework.

In ML, hyperparameter optimization is a crucial stage. OPTUNA was used in this proposed work to improve the untuned DTR model. This research work uses a unique define-by-run style that makes it relatively easy for users to adjust the ML algorithms of hyperparameters. According to OPTUNA, optimizing hyperparameters involves minimizing or maximizing an objective function that receives a collection of hyperparameters as input and outputs the function score. Without relying on externally supplied static constants, this function dynamically creates the search space of neural network architecture based on the number of layers and hidden units. A trial object is a special OPTUNA trace object that looks for the ideal value based on the hyperparameter's name and range. Through interaction with a trial object, OPTUNA gradually constructs the target function and, when the target function is being executed, uses the trial object to dynamically develop the search area. There are two types of sampling methods in OPTUNA: independent sampling and relational sampling. The correlations between parameters are exploited by relational sampling. The relationships between the parameters were not taken into consideration by independent sampling. Depending on the work and surroundings, both relational and independent sampling can be cost-effective.

The proposed work describes untuned lazy predict DT regressor model were optimized and the loss function is improved. The OPTUNA framework was utilized to improve the hyperparameters, and the primary loss function was utilized as the enhanced loss function. This research work, hyperparameter tuning of certain parameters are used to get the best hyperparameter model. The 13 hyperparameters, including `ccp_alpha`, `min_impurity_decrease`, `criterion`, `max_leaf_nodes`, `min_weight_fraction_leaf`, `max_depth`, `max_features`, `min_samples_leaf`, `presort`, `min_samples_split`, `random_state`, `min_impurity_split` and `splitter` were chosen for parameter optimization to get best hyperparameter. Although these 13 hyperparameters were chosen for optimization using OPTUNA as shown in table.1.

The hyperparameters are described as follows:

`ccp_alpha` is at each stage of the pruning procedure, the cost difficulty pruning route which yields the real alphas and the related total leaf impurity. More of the tree is trimmed as alpha rises, growing the overall impurity of the leaves.

`Criterion` is a function that assesses a split's quality.

`max_depth` is the most levels that can be in each tree.

`max_features` is the most features that are taken into account while dividing a node.

`min_samples_leaf` represents samples that must be sorted at least once into a tree leaf.

`min_samples_split` represents minimum number of samples required in a node for node splitting to occur.

`max_leaf_nodes` represent hyperparameter controls the growth of the tree by imposing a condition on the node splitting.

`min_impurity_decrease` represents if splitting the node results in an impurity decrease higher than or equal to this value, the node will be divided.

`min_weight_fraction_leaf` is the percentage of input samples arrives in leaf node this addresses the issue of class imbalance. When `presort` is enabled, the problem will first be sorted and then permuted.

`random_state` is the component in charge of randomization during division. It may be an instance of `RandomState` or an int. The default value is `None`.





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RESULTS AND DISCUSSION

In this study, Jupiter IDE and Google Colab are used to help produce and distribute documents that can be explained using text, live code, and visualizations. After collection, the dataset is divided into 70% train and 30% test. In addition, the tunability hyperparameter made use of Seaborn, Sklearn and Pandas. All kind of regression techniques have been implemented by the given specified tools which assist in identifying the efficient untuned regression technique in prediction. In this research DT regressor, LGBM regressor and KN regressor is identified top three model are taken into consideration with an untuned model. Using 25% of the dataset, the accuracy of the trained model is evaluated. Regressions, in contrast to classification issues, yield a numeric value within a range rather than absolute binary values. An algorithm's errors can be measured using a variety of metrics.

Mean Squared Error (MSE): The average of the discrepancies between the actual and anticipated values. The outcome is never going to be negative. Better outcomes are those that are nearer zero.

$$MSE = \frac{\sum_{i=1}^n (at_i - pt_i)^2}{n}$$

Here at_i represents actual time pt_i represents predicted time, n represents number of predictions

Root Mean Square Error (RMSE): This formula calculates the total average magnitude of the error using a quadratic formula. In order to compute it, one must first add up all of the actual and anticipated values difference, squaring the difference value, divide the total by the number of predictions, and then take the square root of the result. The outcome is certain to be positive because the values are rooted and squared. The measured formula is given as

$$RMSE = \sqrt{\frac{\sum_{i=1}^n (at_i - pt_i)^2}{n}}$$

The MSE and RMSE methods are used to assess the accuracy of this trained prediction model.

R-Squared score: It explains how well the model performs. It explains the variance in the response or target variable that the data model's independent variables predict.

R square has a value in the interval [0,1].

$$R^2 = 1 - \frac{SS_{res}}{SS_{tot}}$$

SS_{res} represents the total squares of the data model's residual errors.

SS_{tot} represents the total sum of the errors.

Table 2 displays the outcomes that the models generated. The DT, LGBM, and KN regressor models were shown as graphs with actual values compared to expected values. The graph's linearity indicates how accurate the prediction was. The model is therefore 100% accurate if line $y = x$ the graph is as linear. A scatter plot is the true by projected plot. For the ordinate, the exponential response (Y) is utilised. Another way to visually assess the likelihood of "lack of fit" is via the plot. An impartial prediction to yield anticipated values that, on average, correspond with the observed values. Figure.5, 6 and 7 show the predicted value versus true value plot for DT, LGBM and KN regressor model.

While the points in other models were a little more dispersed, the model with the DTR algorithm gives results from all the scattered point graphs of predicted values against true values that closely resemble the linear graph. Table 2 and Figure 5 demonstrate that, out of all the models considered, the DTR performs the best, with an accuracy of R-squared score of 0.9864. LGBM and KN regressor was performing with an accuracy of R-squared score is 0.9860 and



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0.9859 which is nearly as good as but slightly lesser than DT regressor model. Similarly, the DT regressor model performs better prediction in RMSE and MSE whereas as in LGBM and KN regressor model performs higher error rate prediction than DT regressor model. The DTR model was therefore fitted with these hyperparameters, which were optimised using the proposed OPTUNA framework In comparison to existing classification methods, the experimental results of the proposed model show higher values for various evaluation metrics when the accomplished prediction model is checked for accuracy using R squared score. Table.3 and Figure.8 displays results of model with improved classification performance based on hyperparameter optimization to get best hyperparameter compared to other models was introduced. The proposed OPTUNA based DT Regressor model achieved a R-Squared of 0.987, a MSE of 2120385948.23, and an RMSE of 46047.6486.

CONCLUSION

This paper has discussed about understanding the relationship between on-time performance and bus ridership is crucial for urban planners, transportation authorities, and policymakers to make informed decisions that enhance the efficiency and appeal of bus services, ultimately contributing to more sustainable and accessible urban transportation systems. In this study, regression-based datasets are solved using the LP classifier for chosen the best model that generates high classification accuracy of R squared score for DT regressor is 0.9864 has been improved through optimizer and hyper parameter. The most sophisticated hyperparameter optimisation framework was used in this research to optimise the prediction model's hyperparameters, which allowed for an accurate estimation of the demand for bus transportation over a certain time period based on passenger transit. The model accuracy of R squared score is improved through OPTUNA with an increase of 0.987 for DT regressor model which is more likely to be suitable in the percentage of buses that depart from their starting point or arrive at a destination based on passenger transportation is one factor used to estimate on-time performance. It can facilitate the usage of public transportation and allow transportation authorities to effectively allocate their limited resources.

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Table.1 DT regressor hyperparameter optimized using OPTUNA

S.No	hyperparameter name	Untuned parameter	Tuned parameter
1	ccp_alpha	0.0	0.0322
2	criterion	MSE	MSE
3	max_depth	None	12
4	max_features	None	Sqrt
5	max_leaf_nodes	None	None
6	min_impurity_decrease	0.0	0.01423
7	min_impurity_split	None	None
8	min_samples_leaf	1	1
9	min_samples_split	2	2
10	min_weight_fraction_leaf	0.0	9.57418
11	presort	Deprecated	Deprecated
12	random_state	None	None
13	splitter	best	best





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Table.2 Metrics to measure the errors for top three regressor ML model

Algorithm	R-Squared	MSE	RMSE
DT Regressor	0.9864	2361332682.94067	48593.54569
LGBM Regressor	0.9860	2438426254.05480	49380.423793
KN Regressor	0.9859	2456666405.6648	49564.7698

Table.3 Metrics to measure the errors for proposed model

Algorithm	R-Squared	MSE	RMSE
Proposed OPTUNA based DT Regressor Model	0.987	2120385948.23	46047.6486

Subsidiary	Month	Year	Percent On-Time	Ridership	
0	Regional Transit Service	4	2009	84.0	1377039
1	Regional Transit Service	5	2009	83.0	1483123
2	Regional Transit Service	6	2009	82.0	1434123
3	Regional Transit Service	7	2009	83.6	1221534
4	Regional Transit Service	8	2009	83.2	1115882
...
1174	RTS Wyoming	8	2022	96.50	
1175	RTS Wyoming	9	2022	97.00	
1176	RTS Wyoming	10	2022	97.00	
1177	RTS Wyoming	11	2022	95.10	
1178	RTS Wyoming	12	2022	95.95	

1178 rows x 4 columns

Figure.1 Recommended dataset based on randomizing the rows

Figure.2 Pre-processed data

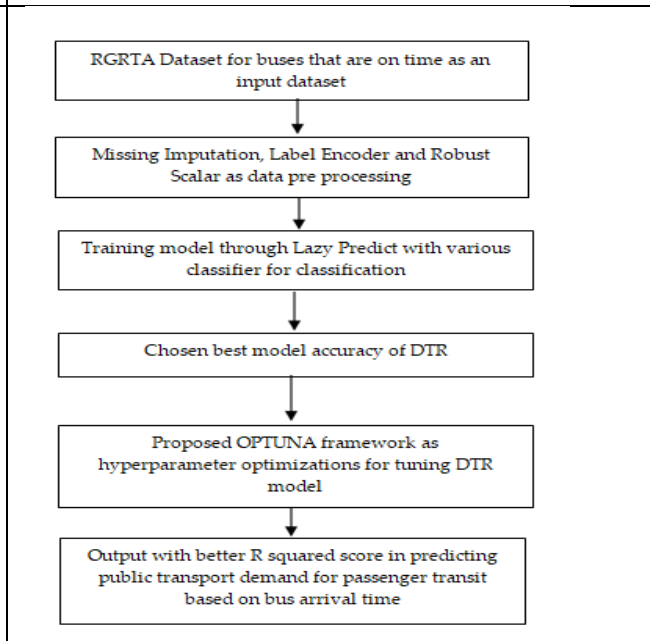
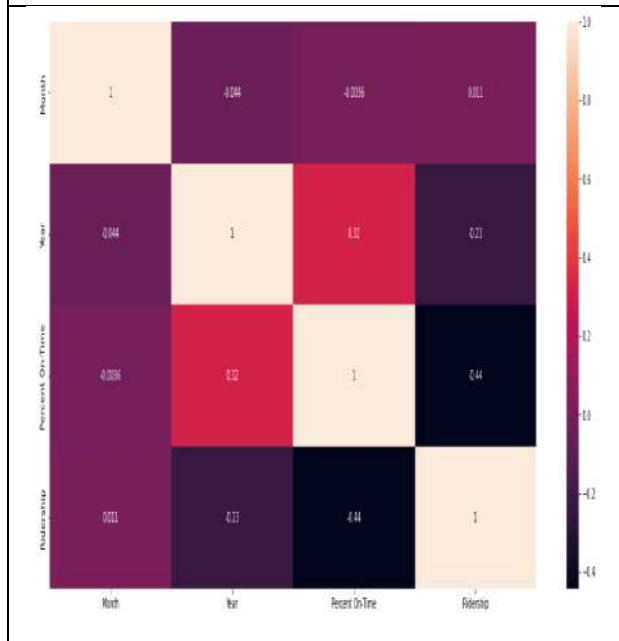


Figure 3 representation of correlation Heatmap

Figure.4 Proposed architecture for predicting transport demand for period of time





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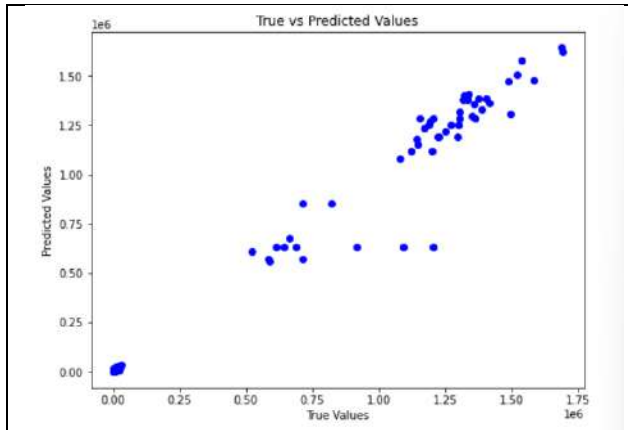


Figure. 5 Predicted versus true value plot for DT regressor model

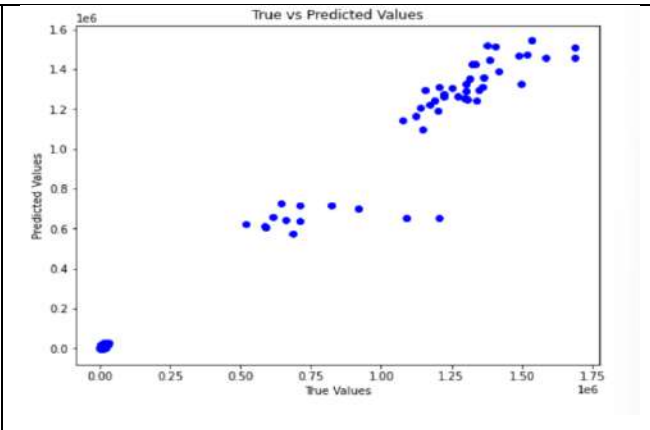


Figure. 6 Predicted versus true value plot for LGBM regressor model

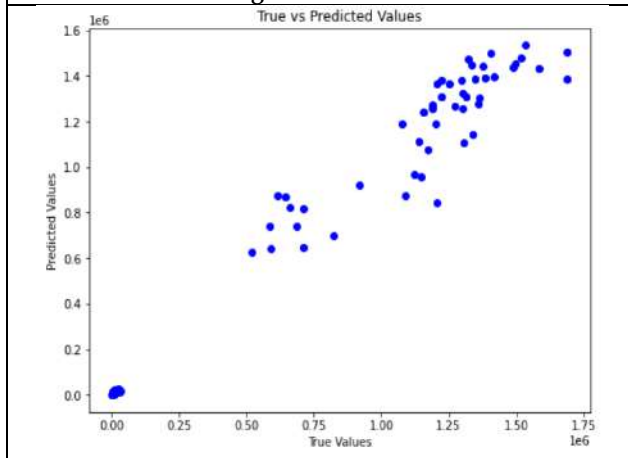


Figure.7 Predicted versus true value plot for KN regressor model

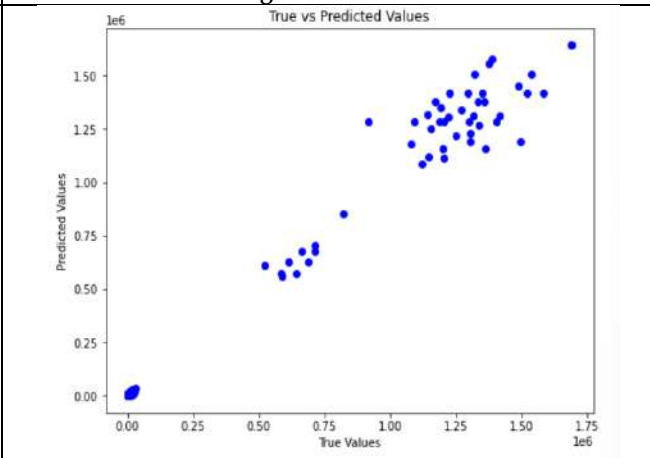


Figure.8 Predicted versus true value plot for proposed OPTUNA based DT Regressor Model





Alchemy: Deciphering the Transformative Effects of Heavy Metals on Namakkal and Cuddalore District of Tamil Nadu, India

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ABSTRACT

Water, the elixir of life, sustains existence across all realms. Its quality stands as a sentinel, guarding against potential threats to human health. Defined by a myriad of factors, water quality denotes its suitability for various purposes, a delicate balance easily swayed by natural and anthropogenic forces. Monitoring its essence involves a symphony of on-site measurements, meticulous sample collection, and analytical scrutiny. At the heart of this vigilance lies the determination of heavy metal concentrations, a critical indicator of water's purity. From the enigmatic depths of cadmium to the shimmering presence of zinc, each metal paints a portrait of potential health hazards. Methods like Atomic Absorption Spectroscopy and Differential Pulse Anodic Stripping Voltammetry serve as the alchemists, revealing the elemental truths within water. Yet, despite our advances in understanding heavy metal toxicity, the specter of poisoning persists, urging us towards proactive prevention and effective remedies. In this quest, the standards set forth by the World Health Organization serve as beacons, guiding our assessments and actions. Water quality, thus, transcends mere chemical composition, encompassing a holistic evaluation of its organic, inorganic, and physiological characteristics. It beckons us to peer beneath the surface, to decipher its secrets, and to safeguard its essence for generations to come.

Keywords: Ground water, Toxic metal, Namakkal, Cuddalore.





INTRODUCTION

In the labyrinthine depths of Namakal and Cuddalore's subterranean realms lies a hidden alchemy, where heavy metals weave a tale of transformation within the groundwater systems. This underground world, often unseen and overlooked, harbors a delicate equilibrium that shapes the quality of this vital resource[1]. As we embark on a journey to decipher its mysteries, we are confronted with the profound impact of heavy metals, both natural and anthropogenic, on these aquifers. The significance of understanding heavy metal contamination in groundwater cannot be overstated, particularly in regions like Namakal and Cuddalore, where reliance on groundwater for drinking and agricultural purposes is paramount. Studies elevated levels of heavy metals such as cadmium, chromium, and lead in groundwater samples from these regions, underscoring the pressing need for comprehensive monitoring and remediation efforts[2]. Furthermore, the work of shed light on the diverse sources of heavy metal pollution in groundwater, ranging from industrial effluents to agricultural runoff. These findings emphasize the multifaceted nature of the problem and the importance of adopting a holistic approach towards mitigation strategies. The analytical techniques employed in assessing heavy metal concentrations play a pivotal role in unraveling the intricate dynamics of groundwater quality. The different research papers showcased the efficacy of Atomic Absorption Spectroscopy and Differential Pulse Anodic Stripping Voltammetry in accurately quantifying heavy metal levels, providing valuable insights for monitoring programs and policy formulation[3]. Moreover, the impact of heavy metal contamination on human health cannot be overlooked. Research conducted highlighted the detrimental effects of prolonged exposure to heavy metals, including neurological disorders, renal dysfunction, and carcinogenicity. These findings underscore the urgent need for stringent adherence to international standards, such as those set forth by the World Health Organization, in safeguarding public health. As we navigate through the intricate web of literature, it becomes evident that unraveling the transformative effects of heavy metals on Namakal and Cuddalore's groundwater systems is not merely an academic pursuit but a crucial step towards ensuring the sustainability and well-being of future generations. Thus, armed with knowledge and determination, we embark on a quest to decipher the underground alchemy that shapes the destiny of these vital water resources.

Water Source and Ground water

Groundwater is the water that saturates the pores and fractures of underground material, such as soil and rock. It exists beneath the Earth's surface within the saturated zone, where the spaces between particles or fractures in rock are filled with water[4]. Groundwater is a vital natural resource, serving as a primary source of drinking water for many communities, as well as playing a crucial role in sustaining ecosystems and supporting agricultural activities. A comprehensive study on the sources and impacts of heavy metal pollution in groundwater. Their findings highlighted the diverse origins of heavy metal contamination, ranging from industrial discharges to agricultural runoff. The study underscored the urgent need for integrated management approaches to address this pervasive environmental challenge. The health implications of heavy metal exposure through contaminated groundwater[5]. Their research revealed alarming rates of neurological disorders, renal dysfunction, and carcinogenicity among populations exposed to elevated levels of heavy metals. The study emphasized the critical importance of stringent regulatory measures and remediation efforts to safeguard public health.

Physiochemical Quality of Ground water

Physico-chemical quality refers to the attributes of water encompassing its color, taste, and potential to induce toxicity reactions or unexpected physiological responses, such as laxative effects. Additionally, it encompasses any objectionable effects encountered during regular use. This definition, as outlined by the World Health Organization (1995), underscores the multifaceted nature of assessing water quality beyond mere chemical composition[6].

Categories of the Water

Different types of water pollution



**Subasri and Vijayan****Urbanization**

The rise in impervious surfaces, amplified runoff from urbanized areas, and heightened discharges from municipal and industrial sources collectively contribute to greater nutrient loading in urban streams. Urbanization typically corresponds with elevated phosphorus concentrations within urban catchments[7].

Radioactive Waste

Radioactive pollution originates from various sources, including radioactive sediment, water utilized in nuclear atomic plants, the exploitation of radioactive minerals, nuclear power plants, and the utilization of radioisotopes in medical and research applications. It is characterized by the presence of radioactive materials in water[8]. Radiation monitoring encompasses the measurement of radiation dose or radio nuclide contamination, serving purposes related to the assessment or regulation of radiation exposure.

Heavy Metal Pollution

Heavy metal poisoning refers to the excessive accumulation of heavy metals in the body's soft tissues, reaching toxic levels. Metals like zinc, copper, chromium, iron, and manganese can accumulate in concentrations high enough to induce poisoning. Industrial exposure, pollution of air and water, medications, and improperly coated food containers are potential sources of heavy metal poisoning[9].

METHODOLOGY**Heavy Metals Analysis**

Heavy metal concentrations in drinking water are commonly assessed using techniques such as Atomic Absorption Spectroscopy and Differential Pulse Anodic Stripping Voltammetry (DPASV). Typically, water samples are collected directly from taps after running the water for at least 5 minutes to stabilize variations in electrical conductivity and temperature. These samples are then acidified to 1% with nitric acid and stored in 500 mL double-capped polyethylene bottles. The resulting heavy metal concentrations are compared with national and international standards such as those set by WHO-2008, USEPA, EPA, and EUC[10]. Any deviations from the maximum permissible limits are noted, and the potability of the water for the selected region is determined based on these findings.

Heavy metal sources

With the swift pace of industrialization and the adoption of consumerist lifestyles, the sources of environmental pollution have multiplied[11]. Pollution arises both during industrial production processes and through the end-use of products, as well as from runoff. These hazardous elements predominantly infiltrate the human body via food and water, with a lesser extent of exposure occurring through inhalation of polluted air, use of cosmetics, medications, and low-quality herbal preparations[12].

Heavy metals in essential and non-essential

Below is a table outlining various heavy metals, their sources, and the drinking water standards across different regions of the world.

MATERIALS AND METHODS**Collection of samples**

Water samples were collected randomly from the vicinity of the SIPCOT industrial in Cuddalore and, we are collecting the water samples in different places of Namakal district. All the water samples were collected from the groundwater reservoir, gathered in plastic bottles. Collected samples were used to analyze the to find out the heavy metals[17].



**Subasri and Vijayan****Heavy metals analysis**

Various authors in their research studies followed standard procedures for conducting a comparative study on the concentration of heavy metals in groundwater samples. The methods employed included the use of an atomic absorption spectrophotometer. Groundwater samples were collected and preserved at 4°C using a Thermo coal box with ice packs. Subsequently, these samples were filtered using Whatman 42 filter paper before analysis[18].

Sample Analysis

Groundwater samples underwent analysis for heavy metals such as zinc (Zn), copper (Cu), nickel (Ni), lead (Pb), and cadmium (Cd) using an atomic absorption spectrometer (Perkin Elmer). The instrument settings and operational conditions were meticulously adjusted in accordance with the manufacturer's specifications[19].

Nickel

Nickel is recognized as an essential trace element crucial for human and animal health. The World Health Organization (WHO) recommends a maximum permissible limit of 0.2 mg/L for nickel in groundwater. Analysis of groundwater samples revealed nickel concentrations ranging from 0.01 to 0.04 mg/L, all of which fell below the permissible limit in Namakkal district. Similarly, in the collected groundwater samples, nickel concentrations ranged from 0.01 to 0.06 mg/L, remaining within the WHO's much higher permissible limit for groundwater in Cuddalore district[20].

Cadmium

The World Health Organization (WHO) recommends a maximum permissible limit of 0.01 mg/L for cadmium in groundwater. However, analysis of groundwater samples indicated cadmium concentrations ranging from 0.01 to 0.05 mg/L. In nearly all groundwater samples in the district of Namakkal, the concentration of cadmium exceeded the permissible limit. Similarly, in all collected groundwater samples in Cuddalore district, the concentration of cadmium ranged from 0.02 to 0.04 mg/kg, surpassing the maximum much higher permissible limit set by the WHO[21].

Copper

The World Health Organization (WHO) recommends a maximum permissible limit of 2 mg/L for copper in groundwater. Analysis of groundwater samples revealed copper concentrations ranging from 0.02 to 0.10 mg/L, all of which were below the permissible limit. Copper is known to accumulate in the liver and brain, and its toxicity is a primary factor in Wilson's disease. However, in all collected groundwater samples in Namakkal, the concentration of copper exceeded the maximum permissible limit set by the WHO[22]. Copper concentrations in groundwater samples in Cuddalore district ranged from 0.05 to 1.00 mg/kg. It is higher than the Namakkal district ground water.

Lead

According to WHO standards, the permissible limit of lead in water is 0.05 mg/L. However, analysis of groundwater samples in Namakkal, indicated that the concentration of lead exceeded the permissible limit in all collected samples. The concentration of lead in water samples ranged from 0.07 to 0.52 mg/L. Similarly, in groundwater samples in Cuddalore, the concentration of lead ranged from 0.28 to 0.78 mg/kg. In nearly all collected groundwater samples, the concentration of lead surpassed the permissible limit set by WHO. Lead contamination in groundwater is a widespread issue, as it accumulates in various organs such as bones, the aorta, kidneys, liver, and spleen over time[23].

zinc

According to WHO standards, the permissible limit of zinc in groundwater is 5 mg/L. However, analysis of groundwater samples in Namakkal, revealed that the concentration of zinc ranged from 0.01 to 0.10 mg/L, all of which were below the permissible limit. Similarly, in the groundwater samples of Cuddalore, the concentration of zinc ranged from 0.01 to 0.58 mg/kg, also below the WHO's permissible limit but higher than the Namakkal. Zinc is



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an essential trace element crucial for the physiological and metabolic processes of many organisms. Nevertheless, elevated concentrations of zinc can be toxic to organisms.

CONCLUSION

The research findings revealed that the groundwater in Cuddalore district exhibited higher levels of heavy metals compared to Namakkal district. This disparity can be attributed to the presence of numerous SIPCOT (State Industries Promotion Corporation of Tamil Nadu) industries within the Cuddalore district. These industries are known to engage in various industrial processes that may involve the use or release of heavy metals into the environment. The industrial activities conducted by SIPCOT industries, including manufacturing, processing, and waste disposal, often contribute to the contamination of groundwater with heavy metals. Effluents containing heavy metals from industrial processes can infiltrate the soil and eventually seep into groundwater sources, leading to elevated levels of heavy metal concentrations. In contrast, Namakkal district may have fewer industrial activities or a different industrial profile compared to Cuddalore, resulting in comparatively lower levels of heavy metal contamination in its groundwater. This observation underscores the critical role of industrialization and industrial practices in influencing the quality of groundwater resources in different regions.

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Table.1 Characteristics of ground water

Taste and Odor	The perception of taste and odor in drinking water is influenced by the activation of human receptor cells situated in taste buds and the nasal cavity, respectively (WHO, 1984). Evaluating the taste of drinking water commonly involves conducting taste tests, which may include threshold tests or taste rating assessments.
Temperature	The odor of a substance can be influenced by temperature due to the correlation between odor and vapor pressure. Additionally, the growth rate of microbes, some of which produce undesirable metabolites, tends to increase with higher temperatures.
pH	The odor and taste of drinking water can be affected by pH, as it regulates the balance of ionized forms of substances. pH levels typically range from 5.0 to 9.0.
Alkalinity	A rise in alkalinity can lead to a reduction in coloration, with the extent of color loss typically correlating directly with the alkalinity of the water sample, often closely resembling its hardness value.





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Hardness	Hardness in water originates from various sources such as sewage and runoff from soil, especially in areas with limestone formations. The primary ions responsible for water hardness are calcium and magnesium. When the predominant anion is carbonate, it is termed temporary hardness, as it can be eliminated by boiling, unlike the case with sulfates, chlorides, and nitrates.
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Table.2 These categories are divided into five classifications.

WQI RANGE	TYPE OF WATER
<50	Excellent water
50-100	Good water
100,1-200	Poor water
200,1-300	Very poor water
>300	Water unsuitable for drinking

Table.3 Heavy metals and their sources

Heavy Metal	Sources	Drinking Water Standards
Zinc (Zn)	Oil Refining Plumbing Brass manufacturing	According to regulatory standards, the Environmental Protection Agency (EPA) and the European Community both set a maximum concentration of 5 mg/L for certain substances. However, the Regulation of Water Community establishes a stricter limit of 0.1 mg/L for the same substances.
Copper (Cu)	Copper plating Printing	As per regulations, the Environmental Protection Agency (EPA) sets a maximum concentration of 1.0 mg/L for specific substances, while the European Community allows up to 3 mg/L. In contrast, the Regulation of Water Community imposes a stricter limit of 0.01 mg/L for the same substances.
Iron (Fe)	High intake as oral consumption	
Cobalt (Co)	Hip alloy replacement case	
Chromium (Cr)	Steel fabrication Electroplating Textile	As stipulated by regulatory authorities, the Environmental Protection Agency (EPA) mandates a maximum concentration of 0.1 mg/L for certain substances. In comparison, the European Community permits up to 0.5 mg/L, while the Regulation of Water Community maintains a consistent limit of 0.1 mg/L for the same substances.
Lead (Pb)	Batteries Coal Combustion Paint Industry	As outlined by regulatory standards, the Environmental Protection Agency (EPA) enforces a maximum concentration of 0.1 mg/L for specific substances. Conversely, the European Community allows up to 0.5 mg/L, while the Regulation of Water Community maintains a consistent limit of 0.1 mg/L for the same substances.
Arsenic (As)	Atmospheric deposition Mining Pesticides	As per regulatory guidelines, the Environmental Protection Agency (EPA) sets a maximum concentration of 10 mg/L for certain substances. Conversely, the European Community mandates a much lower limit of 0.01 mg/L, while the Regulation of Water Community establishes an even stricter threshold of 0.05 mg/L for the same substances.
Mercury (Hg)	Coal combustion, Fish, Mining, Paint industry, Paper industry, Volcanic	As per regulatory standards, the Environmental Protection Agency (EPA) specifies a maximum concentration of 0.002 mg/L for certain substances. In contrast, the European Community imposes a lower limit





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	eruption	of 0.001 mg/L, while the Regulation of Water Community sets a slightly higher threshold of 0.004 mg/L for the same substances.
Cadmium (Cd)	Plastic Fertilizers Pesticides	According to regulatory guidelines, the Environmental Protection Agency (EPA) stipulates a maximum concentration of 0.005 mg/L for specific substances. Conversely, the European Community sets a higher limit of 0.2 mg/L, while the Regulation of Water Community establishes a much lower threshold of 0.001 mg/L for the same substances.

Table.4 guidelines for drinking water or acceptable ranges set by WHO and NAFDAC.

Heavy Metals	Maximum Concentration (WHO)	Maximum Concentration (NAFDAC)
Zinc	5 mg/l	5 mg/l
Arsenic	0.01 mg/l	0.0 mg/l
Magnesium	50 mg/l	30 mg/l
Calcium	50 mg/l	50 mg/l
Cadmium	0.003 mg/l	0.0 mg/l
Lead	0.01 mg/l	0.0 mg/l
Silver	0.0 mg/l	0.0 mg/l
Mercury	0.001 mg/l	0.0 mg/l

Table.5 Heavy metal concentration of ground water samples in Namakkal district

Heavy metal	Cu	Zn	Pb	Ni	Cd
Maximum	0.10	0.10	0.50	0.04	0.05
Minimum	0.02	0.01	0.07	0.01	0.01
Average	0.06	0.05	0.29	0.02	0.03

Table.6 Heavy metal concentration of ground water samples in Cuddalore district

Heavy metal	Cu	Zn	Pb	Ni	Cd
Maximum	1.00	0.58	0.78	0.06	0.04
Minimum	0.05	0.01	0.28	0.01	0.02
Average	0.52	0.29	0.53	0.03	0.03





Strongly and Total Strongly Irregular Fuzzy Semigraphs

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ABSTRACT

This paper aims to pioneer and discuss the concept of strongly and strongly total irregular fuzzy semigraphs, conducting a comprehensive comparative examination of these two variants. We examine the unique features of strongly irregular fuzzy semigraphs and explore their relevance within the context of strongly totally irregular fuzzy semigraphs.

Keywords: Degrees, Fuzzy Semigraph, Irregular Fuzzy Semigraph, strongly irregular Fuzzy semigraphs, strongly total irregular fuzzy semigraphs.

INTRODUCTION

The introduction of fuzzy semigraphs was subsequently expanded by K. Radha and Renganathan.P [1]. Archana.s and Preethi Kuttipulackal further elevated the field through significant contributions to regular fuzzy semigraphs[2]. N R Santhi Maheswari and K.Amutha contributed in the study of Neighbourly Edge Irregular Graphs [3]. J. Krishnaveni Jeganathan and N R Santhi Maheswari produced significant findings to support strongly irregular fuzzy graphs, developing their core principles in this area. [4]. S.Nithishraj, A. Nagoor Gani and P.Muruganatham have explored the domain On Irregular Fuzzy Semigraphs adding valuable perspectives and findings[5]. This study aims to introduce the concepts of strongly irregular fuzzy semigraphs and strongly total irregular fuzzy semigraphs and





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provides a comparative analysis of the two. In addition, the paper analyses the characteristics of neighbourly and highly irregular fuzzy semigraphs, showing significant findings in the area.

METHODOLOGY

By using nodes, edges, adjacent degrees, and consecutive adjacent degrees, we can determine the characteristics of strongly irregular and total strongly irregular. Then, we may proceed to examine neighbourly and highly irregular fuzzy semigraphs.

STRONGLY AND TOTAL STRONGLY IRREGULAR FUZZY SEMIGRAPH

Definition 2.1: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. The degree of a node v is $d(v) = \sum \eta(E)$ where the summation now encompasses all edges E having v as a terminal node. A fuzzy semigraph \mathcal{G} is considered strongly irregular when each pair of connected nodes in \mathcal{G} have distinct degree. It is represented as $d_{\mathcal{G}}(v)$.

Definition 2.2: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. When every pair of connected nodes in a fuzzy semigraph \mathcal{G} has a distinct total degree, then \mathcal{G} is said to be strongly total irregular. It is represented as $td_{\mathcal{G}}(v)$.

Definition 2.3: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. If the edge degrees of adjacent nodes are distinct, we say that the fuzzy semigraph \mathcal{G} is strongly v -edge irregular. It is represented as $d_e(v)$.

Definition 2.4: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. If every pair of adjacent nodes has a distinct edge total degree, we say that the fuzzy semigraph \mathcal{G} is strongly v -edge total irregular. It is represented as $std_e(v)$.

Definition 2.5: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. When each pair of connected nodes in \mathcal{G} contains a distinct adjacent degree, we say that the fuzzy semigraph is strongly irregular in adjacent degree. It is represented as $d_{g_a}(v)$.

Definition 2.6: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. When each pair of connected nodes in \mathcal{G} contains a distinct total adjacent degree, then the fuzzy semigraph is strongly irregular in total adjacent degree. It is represented as $std_{g_a}(v)$.

Definition 2.7: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. When each pair of connected nodes in \mathcal{G} contains a distinct consecutive adjacent degree, we say that the fuzzy semigraph is strongly irregular in consecutive adjacent degree. It is represented as $d_{g_{ca}}(v)$.

Definition 2.8: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. When each pair of connected nodes in \mathcal{G} contains a distinct total consecutive adjacent degree, we say that the fuzzy semigraph is strongly irregular in total consecutive adjacent degree. It is represented as $std_{g_{ca}}(v)$.

EXAMPLE 2.9: Let $\mathcal{G}: (\sigma, \mu, \eta)$ represent a fuzzy semigraph in a given fig.1

All the nodes have distinct degrees, including the degree, edge degree, adjacent degree, consecutively adjacent degree, and its total degrees. Hence, the semigraph generated is both irregular and a totally irregular fuzzy semigraph as seen in the table above. It is easy to see that $d_{\mathcal{G}}(v) \leq d_e(v) \leq d_{g_{ca}}(v) \leq d_{g_a}(v)$ and $td_{\mathcal{G}}(v) \leq td_e(v) \leq td_{g_{ca}}(v) \leq td_{g_a}(v)$.





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RESULTS AND DISCUSSION

Theorem 2.10 For a fuzzy semigraph $\mathcal{G}: (\sigma, \mu, \eta)$ is referred to $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$, where σ remains a constant function, the conditions i) and ii) are identical, indicating that \mathcal{G} is both a strongly and strongly total irregular fuzzy semigraph.

Proof: Assume σ remains a constant function.

(i.e.) $\sigma(p) = c$, for all $p \in v$.

Let us assume a strongly irregular fuzzy semigraph \mathcal{G} , in which each node has a distinct degree.

Consider a pair of nodes P_1 & P_2 , where P_1 and P_2 have distinct degrees T_1 and T_2 respectively.

(i.e.) $d_{\mathcal{G}}(P_1) = T_1$ and $d_{\mathcal{G}}(P_2) = T_2$ where $T_1 \neq T_2$

Suppose that all of the nodes in \mathcal{G} have the same total degree if \mathcal{G} is not a strongly total irregular fuzzy semigraph.

$$\Rightarrow d_{\mathcal{G}}(p_1) = td_{\mathcal{G}}(p_2)$$

$$\Rightarrow d_{\mathcal{G}}(p_1) + \sigma(p_1) = d_{\mathcal{G}}(p_2) + \sigma(p_2)$$

$$\Rightarrow T_1 + c = T_2 + c$$

$$\Rightarrow T_1 - T_2 = c - c = 0$$

$$\Rightarrow T_1 = T_2,$$

which is a $\Rightarrow \Leftrightarrow$ to $T_1 \neq T_2$.

Consequently, the implication (i) to (ii) is established by knowing that \mathcal{G} is a strongly total irregular fuzzy semigraph.

Assume that \mathcal{G} is a strongly total irregular fuzzy semigraph. Subsequently, the nodes total degree is all are distinct.

Let p_1 & p_2 be the pair of nodes have distinct total degrees T_1 and T_2 respectively.

Now, $d_{\mathcal{G}}(p_1) \neq td_{\mathcal{G}}(p_2)$

$$\Rightarrow d_{\mathcal{G}}(p_1) + \sigma(p_1) \neq d_{\mathcal{G}}(p_2) + \sigma(p_2)$$

$$\Rightarrow T_1 + c \neq T_2 + c$$

$$\Rightarrow T_1 - T_2 \neq c - c = 0$$

$$\Rightarrow T_1 \neq T_2$$

Therefore, \mathcal{G} is a strongly irregular fuzzy semigraph, which establishes the implication (ii) to (i).

As a result, we can deduce that (i) and (ii) are identical.

Theorem 2.11: For a fuzzy semigraph $\mathcal{G}: (\sigma, \mu, \eta)$ is referred to $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$, where σ remains a constant function, the conditions i) and ii) are identical, indicating that \mathcal{G} is both a v -edge degree in strongly irregular fuzzy semigraph and a v -edge degree in strongly total irregular fuzzy semigraph.

Proof: Let σ remains a constant function.

(i.e.) $\sigma(p) = c$, for all $p \in v$.

Suppose we have a v -edge degree in strongly irregular fuzzy semigraph \mathcal{G} where the edge degree of its nodes all are distinct.

Consider a pair of nodes P_1 & P_2 , where P_1 and P_2 have distinct degrees T_1 and T_2 respectively.

(i.e.) $d_e(P_1) = T_1$ and $d_e(P_2) = T_2$ where $T_1 \neq T_2$

The proof follows a similar structure as the proof of theorem 2.10.

REMARK 2.12: A v -edge strongly irregular fuzzy semigraph and the total degree is highly irregular. Fig.2.

Now, $d_e(p)=0.6$, $d_e(Q)=0.5$, $d_e(R)=0.7$, $d_e(S)=0.8$, $d_e(T)=0.4$ and $td_e(p)=1.3$, $td_e(Q)=0.9$, $td_e(R)=1.3$, $td_e(S)=1.3$, $td_e(T)=1$. In this case, the nodes of the semigraph have distinct edge degrees and are considered strongly irregular, and the total edge degree of the nodes is also distinct. Therefore, the fuzzy semigraph is highly irregular in total edge degrees.





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Theorem 2.13: For a fuzzy semigraph $\mathcal{G}: (\sigma, \mu, \eta)$ is referred to $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$, where σ represents a constant value, the conditions i) and ii) are identical, indicating that \mathcal{G} is both an adjacent degree in strongly irregular fuzzy semigraph and an adjacent degree in strongly total irregular fuzzy semigraph.

Proof: Let σ remains a constant function.

(i.e.) $\sigma(p) = c$, for all $p \in v$.

Suppose we have an adjacent degree irregular fuzzy semigraph \mathcal{G} where the adjacent degree of its nodes all are distinct.

Consider a pair of nodes P1 & P2, where P1 and P2 have distinct degrees T_1 and T_2 respectively.

(i.e.) $d_{\mathcal{G}_a}(P_1) = T_1$ and $d_{\mathcal{G}_a}(P_2) = T_2$ where $T_1 \neq T_2$

The proof follows a similar structure as the proof of theorem 2.10.

REMARK 2.14: An adjacent degree is neighbourly irregular fuzzy semigraph and its total degree is strongly irregular. Fig.3.

Now, $d_{\mathcal{G}_a}(p)=0.7$, $d_{\mathcal{G}_a}(Q)=0.6$, $d_{\mathcal{G}_a}(R)=0.9$, $d_{\mathcal{G}_a}(S)=0.8$, $d_{\mathcal{G}_a}(T)=0.6$ and $td_{\mathcal{G}_a}(p)=0.9$, $td_{\mathcal{G}_a}(Q)=1.1$, $td_{\mathcal{G}_a}(R)=1.2$, $td_{\mathcal{G}_a}(S)=1$, $td_{\mathcal{G}_a}(T)=1.3$. In this case, the nodes of the semigraph have distinct adjacent degrees and are considered neighborly irregular, and the total adjacent degree of the nodes is also distinct. Therefore, the fuzzy semigraph is strongly irregular in adjacent total degrees.

Theorem 2.15: For a fuzzy semigraph $\mathcal{G}: (\sigma, \mu, \eta)$ is referred to $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$, where σ remains a constant function, the conditions i) and ii) are identical, indicating that \mathcal{G} is both a consecutive adjacent degree in strongly irregular fuzzy semigraph and a consecutive adjacent degree in strongly total irregular fuzzy semigraph.

Proof: Let σ remains a constant function.

(i.e.) $\sigma(p) = c$, for all $p \in v$.

Suppose we have a consecutive adjacent degree irregular fuzzy semigraph \mathcal{G} where the consecutive adjacent degree of its nodes all are distinct.

Consider a pair of nodes P1 & P2, where P1 and P2 have distinct degrees T_1 and T_2 respectively.

(i.e.) $d_{\mathcal{G}_{ca}}(P_1) = T_1$ and $d_{\mathcal{G}_{ca}}(P_2) = T_2$ where $T_1 \neq T_2$

The proof follows a similar structure as the proof of theorem 2.10.

REMARK 2.16: A consecutive adjacent degree is strongly irregular fuzzy semigraph and its total degree is neighbourly irregular. Fig.4. Now, $d_{\mathcal{G}_{ca}}(p)=0.5$, $d_{\mathcal{G}_{ca}}(Q)=0.7$, $d_{\mathcal{G}_{ca}}(R)=1$, $d_{\mathcal{G}_{ca}}(S)=1.1$, $d_{\mathcal{G}_{ca}}(T)=0.9$, $d_{\mathcal{G}_{ca}}(U)=0.6$ and $td_{\mathcal{G}_{ca}}(p)=1.2$, $td_{\mathcal{G}_{ca}}(Q)=1.1$, $td_{\mathcal{G}_{ca}}(R)=1.9$, $td_{\mathcal{G}_{ca}}(S)=1.2$, $td_{\mathcal{G}_{ca}}(T)=1.6$, $td_{\mathcal{G}_{ca}}(U)=1$. In this case, the nodes of the semigraph have distinct consecutive adjacent degrees and are considered strongly irregular, and the consecutive adjacent total degree of the nodes is also distinct. Therefore, the fuzzy semigraph is neighborly irregular in consecutive adjacent total degrees.

Theorem 2.17: For a fuzzy semigraph $\mathcal{G}: (\sigma, \mu, \eta)$ is strongly irregular fuzzy semigraph then it is both highly irregular and neighbourly irregular fuzzy semigraph.

Proof: Let \mathcal{G} be a strongly irregular fuzzy semigraph. It follows that every pair of nodes in \mathcal{G} has distinct degrees. Clearly, it is obvious that every consecutive pair of nodes in \mathcal{G} has distinct degrees, and each node in \mathcal{G} is connected to nodes with distinct degrees. Consequently, \mathcal{G} can be defined as a neighbourly irregular and highly irregular fuzzy semigraph.

Theorem 2.18: For a fuzzy semigraph $\mathcal{G}: (\sigma, \mu, \eta)$ is highly irregular and neighbourly irregular fuzzy semigraph is not required to be a strongly irregular fuzzy semigraph.





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Proof: The nodes P&Q of \mathcal{G} , which are neither adjacent nor incident on the same node can have the same degree, contradicting the definition of a strongly irregular fuzzy semigraph.

CONCLUSION

This study, conducted a comprehensive analysis of strongly irregular and totally strongly irregular fuzzy semigraphs, delving into their edge, adjacency, and consecutive adjacency degrees. A thorough comparative investigation between strongly irregular and strongly total irregular fuzzy semigraphs was carried out, along with a detailed examination of neighbourly and highly irregular fuzzy semigraphs.

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Table:1

END NODES	P	R	T
$d_{\mathcal{G}}(v)$	0.6	0.9	0.4
$d_e(v)$	0.6	0.9	0.4
$d_{\mathcal{G}_a}(v)$	1.2	1.5	0.4
$d_{\mathcal{G}_{ca}}(v)$	0.6	1	0.4
MIDDLE NODES	Q		
$d_{\mathcal{G}}(v)$	0		
$d_e(v)$	0.5		
$d_{\mathcal{G}_a}(v)$	1.1		
$d_{\mathcal{G}_{ca}}(v)$	1.1		
MID- END NODES	S		
$d_{\mathcal{G}}(v)$	0.7		
$d_e(v)$	0.7		
$d_{\mathcal{G}_a}(v)$	0.7		





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$d_{G_{Ca}}(v)$	0.7		
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Table:2

END NODES	P	R	T
$td_G(v)$	1.4	1.6	1.3
$td_e(v)$	1.4	1.6	1.3
$td_{G_a}(v)$	2	2.2	1.3
$td_{G_{Ca}}(v)$	1.4	1.7	1.3
MIDDLE NODES	Q		
$td_G(v)$	0		
$td_e(v)$	1		
$td_{G_a}(v)$	1.6		
$td_{G_{Ca}}(v)$	1.6		
MID- END NODES	S		
$td_G(v)$	1.2		
$td_e(v)$	1.2		
$td_{G_a}(v)$	1.2		
$td_{G_{Ca}}(v)$	1.2		

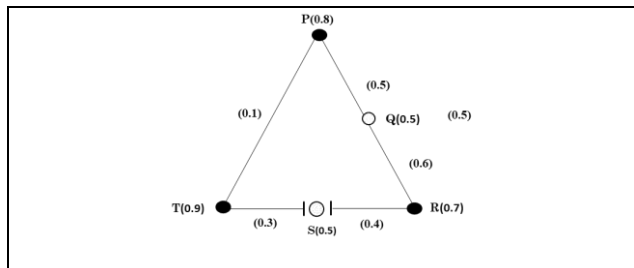


Fig-1

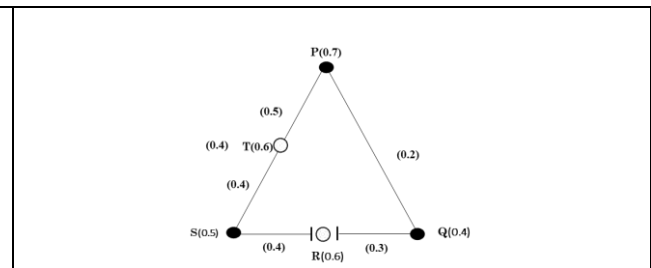


Fig-2

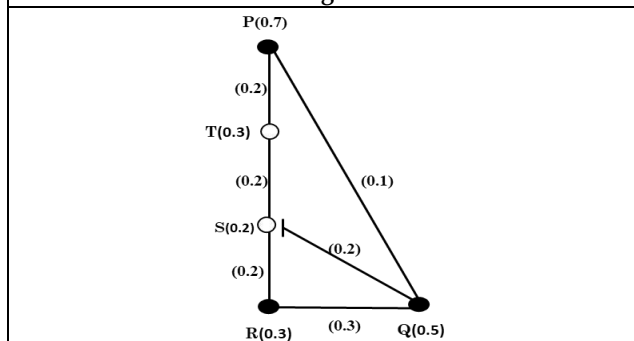


Fig-3

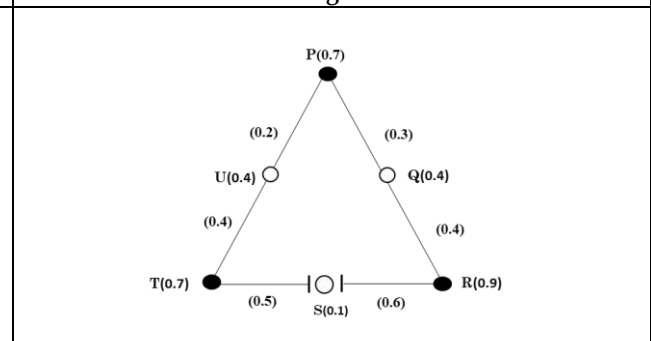


Fig-4





Implementation of Medication Emergency Disease Prediction and Prescription Providing System using Machine Learning

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ABSTRACT

The undertaking of the goal of the Health-Care- Search The engine is to develop applications for illness prediction. The concept was to create an application that would let any user look up the therapy for the illness they were suffering from. The program would then send out a list of steps that needed to be taken in order to treat the disease effectively, along with Information about which Caregivers could help them. A Sizable dataset of medical records, comprising several patients. Demographic and clinical characteristics like age, gender, Medical history, lifestyle choices, and vital signs reused Train the suggested model. A sizable collection of medical records are used to train the Model, which then forecasts the probability of contracting a certain illness. This suggested method bases the disease prediction on the patient's features. and applies the MLP- Algorithm. Input, output, and one or More hidden layers with many neurons stacked on top of each Others comprise a Multilayer-Perceptron. Furthermore, neurons A Multilayer- Perception can employ any arbitrary activation function, but neurons in a perceptron must have activation function that enforces a threshold, such as ReLU or sigmoid. Through collaborative Filtering, the proposed work ensures that the system recommends suitable caregivers. for the patients. A patient provides his Health-Information to the service platform upon Enrolling in this system in order to Receive Professional Care Services. The platform then searches the patient database for other patients who may have comparable health information. Subsequently, the platform for services can monitor which highly rated caregivers attended to these comparable patients. Lastly, the patient may Receive Recommendations from the service platform for these rated caregivers. The patient can locate suitable healthcare. Services that are more likely to offer high-quality care services by using this type of collaborative filtering.

Keywords: Upload Dataset, Dataset Training, Input Query Data, Multilayer Perceptron, Disease Prediction, Rating/Review Analysis, Solution Recommendation





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INTRODUCTION

MACHINE LEARNING

Artificial intelligence (AI) and machine learning allow systems to automatically learn from experience and get better at it. Without needing to be explicitly designed. The Creation of Computer programs that can access data and utilize it to Learn for themselves is the main goal of machine learning. In Order to find patterns in the data and use the examples we provide. Guide future decisions, learning starts with Observations of Data, such as examples, first hand experience, or instruction. The primary objective is to empower computers to learn. their own, devoid of human assistance or intervention, an Adjust their operations accordingly. Machine-Learning is utilized in a variety of AI-Applications including Recommender Systems, driverless cars, Picture an Speech recognition, natural language processing, and more Large-scale Data Processing, Patterns, and Relationships Recognition And Decision-making based on Information is all necessary for these applications. Other Subfields of artificial intelligence (AI) include robotics. expert systems, knowledge representation, planning, and reasoning addition Machine-Learning. Although Echo These subfields focus on a distinct facet of AI; they are all connected and can cooperate to develop increasingly Sophisticated AI-Systems All things considered, machine learning is a vital part of Artificial intelligence (AI) is responsible for helping Computers learn and become more efficient in a variety of Activities. Machine- learning will probably remain a Component in allowing computers to develop intelligence. Beyond that of humans, artificial intelligence (AI) is developing.

DISEASE PREDICTION

Disease risk assessment, which entails projecting a person's probability of contracting a specific disease, is a crucial responsibility in the healthcare industry. Analyzing Variety of risk factors, including age, gender, lifestyle, medical history, and genetic susceptibility, can help achieve this. Large healthcare databases and sophisticated machine learning algorithms make it feasible to precisely estimate the risk of disease and provide individualized preventive measures. Utilizing a dataset, the process of assessing the risk of a disease entails gathering and preprocessing data from a variety of sources, including genetic, medical imaging, and electronic health records. Next, machine learning methods like logistic regression, decision trees, random forests, and neural networks are used to examine this data. Accurate disease risk assessment is made possible by these algorithms' ability to recognize patterns and connections between different risk factors in disease outcomes. The Outcomes Of a disease risk assessment can be utilized to create individualized preventative plans that include dietary adjustments, early detection, and focused medical treatments. This can enhance people's health outcomes and lessen the overall burden of disease. All things considered, illness risk assessment utilizing datasets and machine learning algorithms has the potential to transform the healthcare industry and allow tailored preventive measures that can enhance patient outcomes and lower medical expenses. The goal of the proposed project is to automate the laborious process of looking for and locating hospitals through an automated data-driven strategy for medical knowledge extraction. The plan was to create an application that would enable any user to search for the illness they are experiencing and receive a list of treatments that are successful for it, along with the hospitals that offer the services they need. It is Intend To Accomplish The Following goals.

The majority of search engines employ Keyword-based search, which is a popular method for retrieving documents from the Web. Systems that respond to questions tackle this issue. We Need Tools that let a user Ask a question Uncommon English and get a prompt, concise response with enough context to support the response. The increasing amount of online information available has made it more difficult for users to navigate, which makes the demand for automated question answering systems more pressing. While ranked lists of documents can be returned by current search engines, they do not provide the user with answers. When a search engine is asked a question, it must first assess it, maybe considering the context of an ongoing interaction; it next has to reference links to discover one or more responses; finally, it needs to present the user with the ideal response based on user ratings. These days, patients search online for first aid recommendations and solutions for their medical conditions. Patients wish to receive medical advice about their health and suggestions by asking and





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responding to doctors around the world. The Physicians Recommending them instead Of The intricate and difficult problems. In the beginning, we relied on an external dictionary to find relevant medical information, but this wasn't really enough to assist patients using internet services. These days, we combine medical terminology that creates a barrier between patients and healthcare practitioners with corpus aware terminology that is employed with the use of normal language.

RELATED WORK

Kose,et.al,...[1]outlined a system that contrasts the impact of the multiple imputation methods, MICE and FAMD, on the differential diagnosis performance of DL. Deep Learning is a technique that has grown a lot in popularity recently. Unlike machine-learning-Algorithms, Researchers can use all available data using DL-Modells because they don't add fake reputations. However, quick, dependable and repeatable analysis can yield results and allow for the creation of more accurate estimates [49]. Even in cases, where the dataset contains missing observations, the employment of a high number of neurons in deep learning ensures a comprehensive representation of the available raw data. Upon Reviewing The Literature, if this then that, while deep- learning-techniques have been widely employed in recent research, no study has assessed the performance of missing- imputation-techniques in tandem with their use. For an extended period, it has been recognized that a significant issue in actual clinical trials is the rate of missed observation. Clinical data are known to exhibit distinct features for every disease, novel medication, and treatment approaches. as a result, we only included the Application-Data that we utilized for the Study-Title in our findings and results. Das war eine der Studie Limitations, and we made sure to emphasize it rather clearly. We anticipate having the chance to use our methodology on various clinical datasets, such as electronic medical records or medical imaging genomics. In Conclusion, Deep Learning enables estimates with partial Datasets, in contrast to Machine-Learning-Technikon. Für Hybrid-Type-Daten, is test recommended, dass the Deep- Learning-Method be used in combination with suitable Imputation-Techniques, in order to get the maximum Accuracy-Rates.

Khan,et.al,...[2]Internet of Things Framework is suggested to use a modified deep convolutional-neural- network (MDCNN) to assess heart disease more precisely. Blood pressure and an electro cardiogram (ECG) are monitored by the patient's smart watch and heart monitor gadget. The received sensor data is classified as normal or pathological using the MDCNN. By contrasting the suggested MDCNN with current deep learning-neural- networks and logistic regression, the system performance is examined. The patient's heart condition can be predicted using an MDCNN in the suggested approach. The System is tested and trained for this purpose. The MCNN classifier is used to train the system using the UCI, Framingham, and Public Health Datasets as training data. The data's classified outcomes (normal and abnormal) are included in the UCI dataset. Direct testing of the IoT-Sensor-Values results in a longer time to disease detection and a higher chance of an incorrect result. As a result, the system is trained. Three Steps are involved in training the proposed MDCNN classifier: (i) preprocessing, (ii) feature selection, and (iii) classification. The training's results fall in two categories: (a) normal, meaning the patient's heart condition is normal, and (b) abnormal, meaning the patient's heart condition is abnormal. Testing is done after the training process. Sensor Values are continuously sent by the patient-attached sensor device. The IoT-Sensor-Data are compared with the training-Phase- Values, in order to classify these based on the training- Outcomes. After comparing the values, the system produces results that are classified. Kathamuthu, et.al,... [3] With reduced encryption and decryption time, a novel framework called the deep Q- learning-based neural network with privacy preservation approach (DQ-NNPP) was created to secure data transmission from outside threats. Hospital applications require private patient data, which is uploaded in centralized locations. These Data are then used by Machine-Learning- Techniques to identify distinctive Patterns that can be used to create new Models. Insider- and Outsider-Dangers arise, we Such confidential information is made available to the workers of the organization, or if the company's dataset is compromised. Neural-Network-Techniques are employed in the built model to protect the confidentiality and security of medical records. The System has to get rid of illegal access to the Cloud Storage because it is facing multiple intermediate attacks. After user data is collected, features are taken out and saved for each request, in order to examine malware-activity as well as security- and privacy-related problems. Feature states can be used to extract





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the quality-value the data from these Features, and the actions that correspond to these Features also aid in determining the quality of the data. preservation technique (DQ PP) architecture. In order to provide a patient-centric access control strategy employed in the electronic medical sectors, this study developed innovative cipher text-policy attribute-based privacy preservation (CPA BPP), which combines the advantages of private, public, and master keys, thereby guaranteeing security and privacy. Koppu, et.al,... [4] The prediction model's step-by-step implementation, which includes cleaning, feature extraction, and classification, satisfies this goal. The Cleaning procedure consists of clearing out missing values and detecting outliers using entropy-correlation and sp lines' interpolation. Principle Component Analysis is then used to extract features from the cleaned data. To choose the best features, a Fitness-oriented Dragon-Fly-Algorithm is presented. The resulting Feature-Vector is then put in the Deep Belief Network. The suggested scheme's overall accuracy was tested using conventional state-of-the-art models. The first phase involves applying the gathered information on breast cancer and heart disease to the data cleaning procedure. The cleaning procedure consists of two steps: Outlier detection comes first, followed by missing value filling. Hier ,the Outlier detected using correlation-based approach and entropy, while Sp line Interpolation (SI) is utilized to fill in missing values. The Second Phase Involves using Principal Component Analysis (PCA) to extract features from data that have been cleaned. The third stage involves multiplying the features collected from PCA by a weight function to create a different type of feature vector.

The resulting feature vector is sent to the Deep Belief Network(DBN)architecture in the fourth stage. The Primary contribution is the optimized tuning the multiplied weight through the use of modified, or F-DA, to reduce the error between the anticipated and actual output during the classification process. The Labels, that indicate whether or not the patient is affected, are provided by the Categorization- Output. Ma,Zhuoran,et.al,...[5]suggested PHPR, a high-accuracy, privacy-preserving external disease predictor on random forests. The PHPR-System can create accurate predictions and conduct secure training using medical data that owned by several Data-Owners. Furthermore, original data and computed results in the rational sector can be processed and kept in the Cloud safely and securely without compromising privacy. Specifically, to ensure computation correctness and handle outsourced operations on-the-fly, we first build privacy preserving computation protocols over rational numbers. Next, we show that the PHPR-System is capable of achieving a secure Illness-Predictor. Assume for the purposes of the proposed model that KC is a reliable source that offer critica distribution generating services. While diligently adhering to the prescribed protocol, DOs, CU,OP, and CP are inquisitive, yet truthful parties, that make an effort to discover as much personal information as they can from other parties and the interim outcomes of the learning process. Furthermore, every DO's Data Privacy needs to be protected to the fullest extent possible from both other DOs and Cloud Server (OPorCP). Furthermore, OP end CP are independent cloud servers with a solid reputation, and are not permitted for them to collude, since doing so would be detrimental to their credibility and interest.

BACKGROUND FUNCTION

An effective and private-preserving online disease risk assessment method spanning multiple-outsourced vertical datasets has been established in the current system. This method allows the-healthcare provider safely train a disease risk prediction model using vertically dispersed medical data from several medical centers and offer users privacy-preserving disease risk prediction services. Users' private information as well as that of medical facilities and e-healthcare providers can be securely protected throughout the process. First, it successfully trains a model for disease risk prediction using vertically dispersed data, and it allows for dynamic model updates. With this method, the e-healthcare provider can also successfully trainthe disease risk prediction model,even if medical center gather various attributes from cases. Furthermore, a method for upgrading the model is developed that enables healthcare facilities to submit newly obtained patient data in order to routinely update the prediction model. Second, it offers privacy preservation for both illness risk prediction and model training. Provide a modified Paillier crypto system for this application so that the prediction model may be safely trained without revealing private information about medical facilities. Additionally, the random masking technique is used in disease risk prediction, maintaining user queries and results regarding disease risk as well as the e-healthcare provider's disease risk prediction model.



**Prathipa et al.,****DISEASE PREDICTION WITH SOLUTION RECOMMENDATION USING MACHINE LEARNING**

The "Health Care Search Engine" projects cutting-edge strategy meant to transform the way people look for healthcare and enhance patient outcomes. Utilizing state-of-the-art machine learning methods, such as Multilayer Perceptron (MLP) algorithms, the project aims to forecast the probability of an illness based on a variety of patient attributes, including vital signs, lifestyle choices, medical histories, and demographic information. With the use of this predictive model, which was trained on an extensive collection of medical records, users will be able to make knowledgeable decisions about their healthcare requirements and receive tailored recommendations for caregivers and therapies. Additionally, the initiative incorporates collaborative filtering techniques to improve the patient-career match making process. Through the examination of comparable patient experience with specific medical illnesses, the system finds and suggests highly rated caregivers who have proven to be adopted delivering quality treatment. In addition to increasing patient happiness, this individualized approach makes high-quality healthcare services more accessible. The proposed project seeks to transform the healthcare search environment by leveraging technology to improve healthcare delivery. It provides a smooth and effective solution for both patients and caregivers.

DATASET PROCESSING

Gather a sizable dataset of medical records for this module that includes a range of clinical and patient demographic information, including age, gender, medical history, lifestyle choices, and vital signs. Next, clean up the data to get rid of any unnecessary characteristics, outliers, or missing values that could compromise the model's accuracy. Using methods such as feature importance analysis, mutual information, or correlation analysis, determine which features are most relevant in influencing the risk of a disease. Use machine learning methods like SVM, logistic regression, or random forest to train a classification model. Cross-validation should be used to assess the model's suitability for generalization. Creating a model and preprocessing the dataset are essential stages in building a machine learning-based disease risk assessment module. These procedures guarantee that the model is reliable, accurate, and suitable for usage in clinical settings.

USER SEARCH QUERY

To protect patient privacy and stop unwanted access to private medical records, a patient verification system based on secret keys can be put in place. Every patient in this system has a distinct secret key that they and the Trusted Authority alone can share. A patient's secret key can be requested by the healthcare practitioner in order to confirm the patient's identification when they seek medical attention. Subsequently, the user can look for disease information by symptom. It is possible to create a disease search engine that relies on symptom queries to assist medical professionals in making diagnoses based on patient symptoms. The healthcare provider causes this system to input the patient's symptoms, and it will look for potential illnesses that match the symptoms.

DISEASE PREDICTION

The task of analyzing the symptoms that the user enters and identifying pertinent characteristics that can be utilized to forecast the illness falls to the user symptoms query processing module. Employing methods such as feature importance analysis, mutual information, or correlation analysis, determine which features are most pertinent to the diagnosis of an illness. The disease prediction module can utilize a machine learning technique, such as SVM classification, to forecast the disease based on the user's symptoms after the pertinent features have been retrieved. After the patient provides the service platform with their disease information, the platform analyzes the data and suggests treatments to the patient. This suggestion is based on the highly regarded physicians who receive treatment from the top k patients. Following acceptance of the medical services, the patient evaluates and assesses the physician.





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REVIEW ANALYSIS

The patient evaluates and ranks the caregiver after receiving the medical services from the caregiver they consulted. The service platform determines if a review is genuine or not, display the genuine reviews, and determines the public's average rating. The same approach should be used to generate reviews and ratings. The service platform will not accept reviews and ratings that the patient does not sign under his secret keys. The Service Platform May Question whether the two signatures are from the same Sybil attacker if it notices similar reviews and ratings within a brief period of time. The ratings can only be approved by the service platform and displayed to the public if they are created by a typical patient, that is, not a Sybil attacker. Ultimately, the distinct and original reviews are safely encrypted and kept in a database.

SOLUTION RECOMMENDATION

The suggested method uses collaborative filtering to suggest suitable cares for the patients. The service platform can keep track of the highly rated care givers who attended to these comparable patients when patients look for the caregiver's solution. Lastly, the patient may receive recommendations from the service platform for these rated caregivers. The patient can locate suitable healthcare services that are more likely to offer high-quality care services by using this type of collaborative filtering.

METHODOLOGY

MULTILAYER PERCEPTRON ALGORITHM

Multilayer Perceptron Algorithm feed forward artificial neural network structure called Back propagation projects a set of input data onto a set of suitable outputs. It consists of many directed graph layers with Multiple Layers of nodes, each fully connected to the following layer. With the exception of the input nodes, each node is a neuron with a nonlinear activation function. Back propagation trains the network by taking advantage of a supervised learning method known as back propagation. Should back propagation possess basic On-off-Mechanism, such as linear activation function in all neurons, to regulate Whether or not a neuron fires, then it is easily proved with linear algebra that any number of layers can be reduced to the Standard Two-Layer-Input-Output-Model. Gradient techniques are therefore useful in Optimization-Strategies to control the Weights and reduce the network's Loss-function. To Computer Gradients for each layer in a feed forward network, a chain of Imperative Rules may be created using the Delta-Rule. For the Back Propagation Algorithm to work, each neuron activation function must differ. Back Propagation is now used in the continuing research on distributed computing, Computational Neuroscience and Parallel Computing. Their ability to solve Complicated Issues and their fitness Approximation of Outcomes, even with crucial Predictions, makes them extremely useful for studying. One of the neural network models, back propagation, use the same feed-forward-back-propagation- architecture as supervised training. The most popular and often used kind of neural network is the back propagation. User can provide the Features and inevitably predict the diseases.

The algorithmic steps are Follow

Step1:Randomly Set The Weights And Biases.

Step 2: Feed the trainings sample.

Step3:Forward Inputs and calculate each unit's Net Input and output in the hidden and output layers.

Step 4: Back propagate the error to the intermediate layer.

Step 5:Update Weights and biases to replicate the propagated Errors. The weights and biases of the network are automatically. Adjusted by mathematical measures called training and Learning Functions.

Step 6: Stop the Condition





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COLLABORATIVE FILTERING

User-based Collaborative Filtering is a Method that leverages ratings from other users who share the target User's taste to predict the items the user could find appealing. Collaborative Filtering is a common technique used by websites to develop their recommendation system. Cold starts for newly added items to the list are one issue that Collaborative Filtering may cause. They receive no recommendations unless they receive a rating. Data Sparsely: Can exacerbate the cold start issue and have an impact on the performance of user-based recommenders. Growing datasets can present scaling challenges, due to their Potential for excessive Complexity. When the Dataset is huge, Item-based Recommenders perform faster than user-based. Ones. If the suggestions were implemented simply, one may Notice that the items from the long tail portion might be disregarded and that the Recommendations are generally already well-liked.

Steps for User-based Collaborative Filtering

Step 1: Finding the similarity of users to the target user U. Similarity for any two users ,a' and ,b' can be calculated. from the given Formula.

Step 2: Prediction of the missing rating of an item The target user may now resemble certain users very. substantially while not like the others at all. Therefore, a Specific item's Ratings from users who are more similar to it should be given more weight than ratings from users who Are less similar to it, and so on. A weighted average method. can be used to tackle this issue.

EXPERIMENTAL RESULTS

The proposed drug recommendation system was implemented in Python as front end and MySQL as backend that allows a developer to create a customized development environment. The experimental results show the output of disease diagnosis using symptoms and also recommend the appropriate drugs for predicted disease. In below, we explained the details with specific screenshots. In fig 2 shows the process of selecting symptoms for prediction disease. Here user can select the symptoms regarding their health issues. For symptoms processing here apply MLP algorithm. In fig 3 shows the process of disease prediction output, the input symptoms are processed using MLP algorithm and predict the disease based on symptoms. In fig 4 shows the process rating posted by user. The registered user can post their ratings for provided drug details. It support Star Ratings,smiley sand text based review system. In fig 5 shows the process of drug recommendation. Based On user's rating, review and feedback, the system analyzed the feedback using collaborative filtering algorithm. Predict the highly positive rate drugs and recommend the predicted drugs to the users.

CONCLUSION

In Conclusion, a promising method healthcare that can enhance patient privacy while yet enabling reliable disease prediction is disease prediction using symptom data with classification disease dataset using the MLP algorithm. The MLP algorithm is an effective tool for classification jobs and has a high accuracy rate for predicting the disease based on the symptoms of a patient. Additionally, the application offers the anticipated illness. Solution vendors have already shared and stored in databases their disease-focused solutions. Patients are able to rate and review a particular remedy online. An effective review analysis is provided by collaborative filtering method. The can obtain the majority of suggested solutions with this strategy. This protects user identity privacy by preventing the service platform, caregivers, and other patients in the system from learning the patient's identity information. In order to prevent phony Reviews of caregivers, deploy and analyze fake reviews has well.





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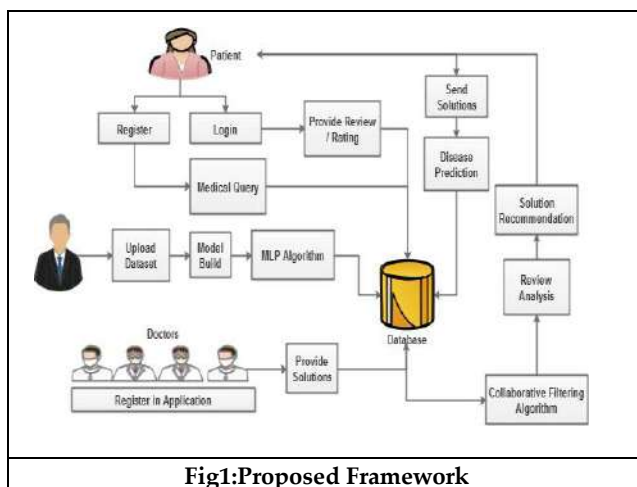


Fig1:Proposed Framework

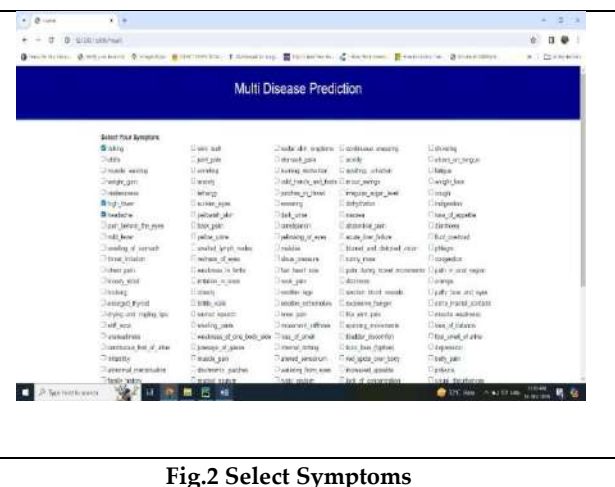


Fig.2 Select Symptoms





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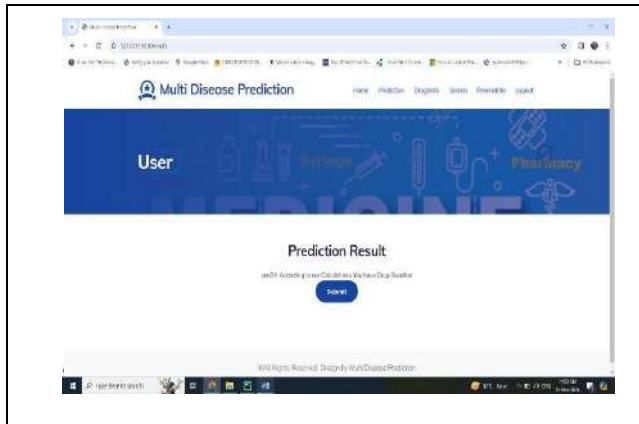


Fig.3 Disease Prediction

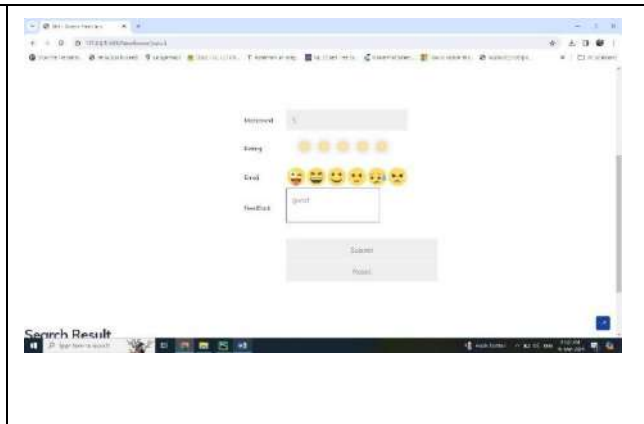


Fig.4 Rating/Review System



Fig.5 Recommendation System





A Survey on Efficient Bandwidth Management in Federated Learning: Exploring Novel Compression Techniques, Adaptive Protocols, and Network Innovations

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ABSTRACT

Federated learning permits the training of decentralized models among several devices while maintaining local data, yet it presents serious bandwidth issues because of the frequent and substantial model changes. Scaling these systems in practical applications requires effective bandwidth control. This study investigates many strategies, including network innovations, adaptive protocols, and compression techniques. We examine techniques including quantization, sparse updates, and model pruning to minimize update sizes without sacrificing accuracy. Adaptive protocols modify communication according to network circumstances and client accessibility, and advances in networks such as asynchronous communication and hierarchical federated learning facilitate faster data transfers. We present an overview of existing research, point out shortcomings, and offer innovative methods to improve the effectiveness and also scalability of the federated learning systems by examining recent developments and trends. This paper aims to guide future research in developing better bandwidth management solutions for federated learning.

Keywords: communication, management, devices, learning, network.



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INTRODUCTION

Artificial intelligence (AI) was first proposed in 1956 and its technological advances are having an increasingly significant impact on human existence[1]. Many application areas have entered the field of artificial intelligence due to recent advances in artificial intelligence technology [2]. In order to advance AI technology, academic research focuses on models, processing power, chip functionality, and further technical difficulties along the way. Large quantities of actual data must be used to train machines to actually imitate human reasoning. Federated learning revolutionizes the field of machine learning by enabling centralized modelling training on a large number of devices, while ensuring that data remains on local devices. The concept of FL was proposed by Google in 2016 primarily to update the model on the Android mobile phone without disclosing confidential personal information [3]. Afterwards, Google implemented an application-focused FL system. Without storing raw device data on cloud servers, the FL system's architecture was designed to run the FedAvg algorithm on mobile devices, conduct federated studies, and be used to monitor statistics for big cluster equipment. The FL is among the most significant technologies in the field of data protection computing. FL's lightweight technology pathways and deployment system have made FL a popular product and solution for many applications involving privacy computing. As FL applications have evolved and grown more complex, a substantial number of research achievements in the field have emerged. This strategy enhances security and privacy while also allows the use of different data sources without the need for centralized data collection.

As long as private data stays inside the local area, FL is a safe distributed machine learning technology that may be used in conjunction with FL algorithms on a number of distributed edge devices and servers [4]. Each local client receives data training tasks from FL, and instead of direct data communication, clients and servers communicate with one another through parameter interaction. Then server's contribution to updating the global model is limited to basic parameter aggregation. By conserving server processing and storage resources, a FL system like this can safeguard local user data. With client-server communication, a superior global model can be produced via FL. The method is in contrast to conventional centralized training, which gathers all local data into the training's central server [5]. In contrast to conventional centralized machine learning techniques [6], FL techniques enable the realization of numerous federated agencies to construct a single, compliant, safe model for multi-source data applications in the ecological system [7].

Federated learning has great potential, but it also has a lot of problems, especially with bandwidth control. Significant bandwidth needs are caused by the frequent and frequently massive model update transfers that occur between clients and the central server. To scale federated learning systems and make them practical for use in real-world applications, effective management of this bandwidth is necessary.

This study investigates novel approaches to address these bandwidth problems, with a primary focus on three domains: network innovations, adaptive protocols, and compression methods. The goal of compression techniques like quantization, sparse updates, and model pruning is to minimize the size of model updates without compromising accuracy. Adaptive protocols maximize bandwidth utilization by dynamically modifying communication processes in response to current network conditions and client availability. Asynchronous communication and hierarchical federated learning are two examples of network improvements that simplify data transfers and cut costs.

Our review focuses on current developments and new trends in these fields. We provide an extensive overview of the field's current situation, point out any gaps in the knowledge, and offer novel ideas for enhancing the efficiency and scalability of federated learning systems. Our goal is to offer guidance and insights for future research aimed at creating more efficient bandwidth management solutions for federated learning through theoretical analysis and real-world examples.



**Sayed Muhammed Fazil and Bharathi**

LITERATURE REVIEW

Federated learning is a relatively recent concept in machine learning that focuses on collaboration rather than centralization or data aggregation. This paradigm shift was earlier introduced by Konečný, McMahan, and colleagues [8] who laid the groundwork in establishing the basic tenets of federated learning—data locality is only between model updates that participants share. Their work (Konečný et al., 2016) raced light-years ahead to open up the potential for protecting privacy while developing collaborative models for training and scattered devices in a natural environment. McMahan and team developed the Federated Averaging algorithm on top of such basic concepts [9] and now become the cornerstone in federated learning. FedAvg can save huge costs in communication, allowing devices to train models locally over a number of iterations before the created models get averaged across the network. It reduces frequency and volume of exchanged data between devices and central servers—for instance, the communication costs incurred locally will be minimized when data is being exchanged between devices and a central server (McMahan et al., 2016).

On the other hand, privacy remains a primary concern in federated learning, especially considering that the data is decentralized. Martin Abadi [10] was the first to work on a way to solve these issues with the design of mechanisms to achieve untraceability of individual data points in the updates of models with differential privacy. While this work is not specifically associated with federated learning, Abadi's work is integral in establishing a proper basis for integrating privacy-preserving techniques in federated systems and ensuring that individual data from the participants are secure and remain private throughout the collaboration training process, whereby the training is close to real time. Federated learning faces a critical challenge: the efficiency of communication, also in the presence of heterogeneous devices in the computational and network capabilities, causes not only a privacy concern. This point is illustrated, for instance, in the work done by Peter Kairouz [11], regarding strategies to optimize federated learning in such heterogeneous settings, through adaptive tuning of communication frequency with respect to network conditions and the model's convergence rate. Such strategies are pivotal in managing bandwidth properly, ensuring that federated learning remains both scalable and effective across devices and networks (Kairouz et al., 2019).

Hence, personalization in a federated learning setting becomes very attractive since one can get the benefit of the model of the federated network fit to each user. An important contribution to this field was made by Tian Li and colleagues [12] when they suggested the use of a meta-learning approach to aid the creation of a personalized model for each client. One of the key aspects of this factoring adaptability is that even federated learning must be customizable to adapt effectively under the consideration of scenarios in the service areas, where user behaviour across regions deviates greatly.

Bandwidth management has been a crucial and extensively researched aspect in the scalability and viability of federated learning. The alleviation occurs through the transmission of only the most prominent updates or by reducing the precision of the data transmitted to relieve the burden on network resources, hence making federated learning more practical in environments with limited bandwidth. Furthermore, Jianqiao Wang [13] has developed a communication-efficient optimization algorithm on SignSGD, when only the sign of incoming gradients is shared between the devices, with a very significant decrease in the transferred data volume, and the model learning is almost not influenced (Wang et al., 2018).

Among the problems of secure aggregation of updates of models, work on the above problems has also been done by Kallista Bonawitz [14] and associates. They built a secure aggregation protocol that would ensure the server at the center would only receive the aggregated updates of all the participating devices, hence protecting individual contributions. This is actually one of the basic requirements for maintaining any form of trust within federated learning systems, especially when sensitive data is involved (Bonawitz et al., 2017). The recent work of Qiang Yang and Peter Kairouz [15] is helpful for those who aim to get the full picture of the current status of federated learning.



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They provide not only detailed descriptions of the latest progress but also highlight open challenges of improving its communication efficiency, privacy, and model personalization in FL (Yang and others, 2019; Kairouz and others, 2021).

Methodologies for Efficient Bandwidth Management in Federated Learning

Federated learning faces significant challenges, particularly with managing bandwidth due to the frequent and large exchanges of model updates. To address these challenges, several methods have been developed, focusing on improving communication efficiency and managing data distribution. Here are some of the basic methods used in this topic:

Model Compression Techniques

In order to save bandwidth, model compression techniques are needed to reduce the number of model updates delivered from clients to the central server. Pruning, as discussed by Han et al. (2016) [16], involves removing unnecessary weights from the neural network without significantly impacting performance. By eliminating less significant weights or nodes, the model becomes sparser and more efficient. For instance, if a neural network initially has 1,000 connections, pruning might remove 500 of the least important ones, effectively halving the model size. Another technique is quantization, which lowers the model parameters' precision to need less data. Data size can be decreased by a factor of four by converting weights and activations from 32-bit floating-point numbers to 8-bit integers, as noted by Gupta et al. (2022) [17]. This essentially means that a weight is transmitted as an 8-bit integer rather than a 32-bit floating-point value.

Sparse updates, although not specifically covered in the provided studies, are a well-established concept in the literature. This technique involves transmitting only the changes in model weights that exceed a certain threshold, significantly reducing communication by sending updates only for parts of the model that have experienced substantial changes. For example, if only 10% of model weights change significantly during training, only these changes are transmitted, potentially reducing communication by up to 90%.

Adaptive Protocols

Adaptive protocols play a crucial role in optimizing communication processes in federated learning systems by dynamically adjusting based on real-time network conditions and client availability. Dynamic client selection, as discussed by Kairouz et al. (2021) [18], involves choosing a subset of clients with optimal connectivity for each training round, thus avoiding delays and reducing bandwidth usage. Their review highlights the effectiveness of this approach in improving communication efficiency by selecting clients with the best network conditions ("Advances and Open Problems in Federated Learning"). Chen (2023) [19] examined adaptive frequency, which modifies the frequency of model updates based on network circumstances and the model's rate of convergence. During periods of high network traffic, this method helps manage congestion by reducing the update frequency to prevent network overload ("Federated Learning Architecture to Integrate AI Models from Different Internet Service Providers: Using Bandwidth Slicing Resource Management as Case Study," *Journal of Computer Networks and Communications*). These studies demonstrate how adaptive protocols, including dynamic client selection and adaptive frequency, improve federated learning effectiveness by adjusting communication according to the situation.

Network Innovations

Network innovations are critical for enhancing the communication infrastructure and protocols in federated learning systems. Hierarchical federated learning, as described by Yang et al. (2019) [20], organizes clients into hierarchical structures to reduce the communication burden on the central server. By grouping clients into clusters with local aggregators, the number of direct connections to the central server is minimized. For example, in a company with multiple branches, each branch could have a local aggregator that consolidates updates and communicates with the central server, effectively lowering the communication load ("Federated Machine Learning: Concept and Applications," *2019 International Conference on Machine Learning*).



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Asynchronous communication allows clients to send updates independently rather than synchronizing all clients at once. This method enables clients to transmit updates based on their local schedules, such as clients in different time zones sending updates when they finish their training rounds. Zhao et al. (2022) [21] highlight the advantages of this approach in managing communication delays and improving scalability ("Federated Learning with Non-IID Data: A Survey"). By streamlining communication protocols and lightening server load, these network innovations—such as hierarchical structures and asynchronous communication—improve the effectiveness and scalability of federated learning systems.

Data and Model Optimization

Optimizing how data is handled and how models are trained can also contribute to more efficient bandwidth use. By combining model updates from clients, Federated Averaging (FedAvg), a key approach in federated learning, improves communication efficiency. According to Kairouz et al. (2021) [22], FedAvg operates by having each client compute its local model updates, which are then transmitted to a central server. Then server averages these updates and makes use of the average to the global model. For example, if three clients each send their model updates, the server calculates the average of these and updates the global model accordingly. The total amount of data that needs to be conveyed is greatly decreased by using this strategy, thus minimizing communication overhead and improving system efficiency ("Advances and Open Problems in Federated Learning"). FedAvg is widely recognized for its effectiveness in managing data transmission in federated learning environments. A method called knowledge distillation uses the information coming from a bigger, previously trained model to train a smaller, more effective model. This method works by having a smaller model, known as the student, learn to replicate the behavior of a larger model, or teacher, by training on the outputs generated by the teacher model. For instance, a lightweight student model might be used on a mobile device, while a more complex teacher model operates on a server, providing the necessary outputs for the student model to learn from. This approach enables the deployment of efficient models in resource-constrained environments without sacrificing performance. The effectiveness of knowledge distillation in federated learning contexts is discussed by Yang et al. (2019), who explore its applications and benefits in making advanced models more accessible and efficient across different devices ("Federated Machine Learning: Concept and Applications").

Privacy-Preserving Techniques

Ensuring data privacy while optimizing communication efficiency is also a key consideration in Federated Learning concept. Differential privacy is the technique designed in order to safeguard the confidentiality of individual data points by adding noises to model updates. This method involves applying mathematical techniques to ensure that the contribution of any single data point is obscured by random noise, making it difficult to trace specific details back to any individual. For example, before transmitting model updates, a client's data may be modified with random noise to mask its origin, thus preserving privacy. Kairouz et al. (2021) discuss differential privacy in their review of federated learning advancements, highlighting its importance in maintaining privacy while still allowing for effective model training ("Advances and Open Problems in Federated Learning"). This method is essential for protecting private data in federated learning systems.

While protecting the anonymity of their inputs, multiple participants can collaborate to jointly calculate a function over those inputs through the use of secure multiparty computing (SMPC). This method employs cryptographic techniques to ensure that no single party has access to all the data, thus preserving privacy throughout the computation process. For example, multiple hospitals can collaborate to train an artificial intelligence model using patient data without actually sharing the individual datasets with one another. This technique is essential for maintaining data confidentiality while enabling collaborative learning. Kairouz et al. (2021) discuss the application of secure multiparty computation in federated learning contexts, emphasizing its role in facilitating privacy-preserving data collaborations ("Advances and Open Problems in Federated Learning").





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CONCLUSION

The bandwidth-efficient management is one of the core elements that shall set federated learning free with its full power, especially as it has always been progressing toward real-world applications. By reducing the communication overhead, data transmission optimization can enhance the distributed learning paradigm's inclusivity and scale. This is going to be very instrumental not only to large-scale AI models but democratizes leading-edge technologies, thereby being more available for lower-end devices. This points to a future of bandwidth management in federated learning driven by adaptive techniques that react in real time to network conditions, with the development of algorithms driving prioritization of essential data without model-accuracy compromise. Other technologies that could be utilized and incorporated to further drive down latency and improve communication efficiency are emerging 5G and edge computing, hence making federated learning systems seamless and responsive. In improving such methods, we should not turn our backs on the ethical considerations at stake but work towards efficient, more equitable, transparent, and fair systems for all, so that the fruits of federated learning are realized by all.

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Table 1: Literature Review

Sl. No.	Author(s)	Year	Title	Dataset Details	Parameter/Measurement Used	Description
1	Yen-Hung Chen	2023	Federated Learning Architecture to Integrate AI Models from Different Internet Service Providers: Using Bandwidth Slicing Resource Management as Case Study	MCTS-level, Self-Adaptive Learning (SAL) method	The level of MCTS is a key parameter that blends sampling techniques with decision trees to approximate optimal solutions for bandwidth slicing, with a higher level MCTS indicating greater throughput and a more thorough investigation of solutions using the Monte Carlo Tree Search (MCTS)	Explores the development of efficient bandwidth slices by cooperation of several Internet service providers (ISPs) using AI-based techniques
2	Wen, J., Zhang, Z., Lan, Y., Cui, Z., Cai, J., & Zhang, W.	2023	A Survey on Federated Learning: Challenges and Applications	CIFAR-10, MNIST, and various benchmark datasets.	Challenges in FL, applications	Provides a comprehensive overview of FL, focusing on challenges, application, and techniques for improving communication efficiency and managing bandwidth





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3	Kartik Gupta, et.al	2022	Quantization Robust Federated Learning for Efficient Inference on Heterogeneous Devices	ImageNet, CIFAR-10	Quantization Robustness, Inference Efficiency, Model Accuracy	Implementation of quantization techniques that reduce the size of the model parameters to improve communication efficiency and reduce the computational burden during inference
4	Yue Zhao, Rongbin Zhang, Songzhu Zheng, Hengshu Zhu	2022	Federated Learning with Non-IID Data: A Survey	Non-IID synthetic datasets, CIFAR-10, MNIST	Data distribution, model accuracy, convergence rate	Surveys challenges and solutions for federated learning with non-IID, or identically distributed but not independent data, focusing on dispersion of data impacts on model accuracy and convergence.
5	Peter Kairouz, H. Brendan McMahan, Brendan Avent, et al.	2021	Advances and Open Problems in Federated Learning	CIFAR10, MNIST, synthetic data	Scalability, communication cost, model accuracy	Reviews recent advances in federated learning, highlighting open problems and future directions, particularly focusing on scalability and communication cost reduction.





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6	Qiang Yang, Yang Liu, Tianjian Chen, Yongxin Tong	2019	Federated Machine Learning: Concept and Applications	CIFAR10, MNIST, health care datasets	Model performance, communication efficiency, privacy preservation	Discusses the foundational concepts of FL, it's potential applications across a range of fields, and key challenges such as communication efficiency and privacy preservation.
7.	Jacob et al.	2018	Quantization and Training of Neural Networks for Efficient Integer- Arithmetic-Only Inference	ImageNet, CIFAR-10	Quantization error, model efficiency	Focuses on Quantization methods for shrinking the model's size updates for efficient federated learning.
8.	Li, T., Sahu, A. K., Talwalkar, A., & Smith, V.	2018	Federated Learning: Challenges, Methods, and Future Directions	MNIST, CIFAR-10	Convergence rate, communication efficiency, scalability	Provides a comprehensive overview of federated learning challenges including communication efficiency, and presents potential solutions and future research directions.
9	Pham et al.	2018	Neural Architecture Search with Reinforcement Learning	CIFAR-10, ImageNet	NAS efficiency, model performance	Uses NAS techniques to design efficient model architectures for FL.





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10.	McMahan et al.	2017	Communication-Efficient Learning of Deep Networks from Decentralized Data	CIFAR-10, MNIST	Communication cost, model accuracy	Introduces Federated Averaging (FedAvg) to reduce communication costs in federated learning with decentralized data.
11.	McMahan, H. B., Moore, E., Ramage, D., & Hsieh, C. J.	2017	Communication-Efficient Learning of Deep Networks from Decentralized Data	CIFAR-10, MNIST, other benchmark datasets.	Communication cost, convergence efficiency, model performance	Proposes Federated Averaging, a key federated learning algorithm that reduces the volume of information that clients and servers must exchange.
12.	Ruder	2017	An Overview of Multi-Task Learning in Deep Neural Networks	Various datasets	Multitask learning performance, efficiency	Provides an overview of multitask learning approaches that can be applied to federated learning for diverse tasks.
13.	Han et al.	2016	Deep Compression: Compressing Deep Neural Networks with Pruning, Trained Quantization, and Huffman Coding	CIFAR-10, ImageNet	Model size reduction, accuracy	Proposes deep compression techniques including pruning and quantization to reduce model size and communication bandwidth.





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14.	Konečný et al.	2016	Federated Learning; Strategies for Improving Communication Efficiency	MNIST, CIFAR-10	Communication efficiency, model accuracy	Discusses various strategies for improving communication efficiency in federated learning setups.
15.	Hinton et al.	2015	Distilling the Knowledge in a Neural Network	MNIST, CIFAR-10	Knowledge transfer efficiency, accuracy	Introduces knowledge distillation to create smaller, efficient models for federated learning.





Nano Targeted Gene Delivery: Advances, Challenges and Future Directions

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ABSTRACT

Nano targeted gene delivery stands as a pivotal innovation in the realm of gene therapy, offering a transformative approach to treating an array of diseases including cancer, genetic disorders, and infectious diseases. This review elucidates the significant strides made in nanotechnology for gene delivery, highlighting the design and application of various nanomaterials such as liposomes, dendrimers, and nanoparticles. These nanocarriers are engineered to enhance the precision, efficacy, and safety of gene delivery, addressing the cellular and molecular intricacies of targeted therapy. Despite the progress, the field grapples with challenges including technical hurdles in nanocarrier design, biological barriers like immune response and targeting accuracy, and ethical and regulatory considerations. Looking forward, the integration of artificial intelligence and interdisciplinary strategies promises to propel the field, optimizing nanocarrier design and broadening the scope of gene therapy applications. The convergence of these advancements heralds a new era in healthcare, where nano targeted gene delivery could revolutionize personalized medicine and offer hope for previously intractable conditions.

Keywords: Nano targeted gene delivery, Nanotechnology, Gene therapy, Personalized medicine, Nanocarriers.



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INTRODUCTION

Overview of gene therapy and its significance in modern medicine

Gene therapy represents a groundbreaking approach in modern medicine, offering potential treatments for a range of genetic disorders, cancers, and infectious diseases that were once deemed incurable. By directly modifying the genetic material of a patient's cells, gene therapy can address the root causes of diseases at the molecular level(1). This approach can lead to long-lasting and potentially curative outcomes, distinguishing it from traditional therapies that often only treat symptoms. The significance of gene therapy extends beyond individual patient benefits, as it also has the potential to reduce long-term healthcare costs and improve overall public health outcomes. (2).The success of gene therapy in treating disorders like spinal muscular atrophy and certain forms of inherited blindness has garnered significant attention, demonstrating its potential to transform medical treatments and offering hope to patients with limited therapeutic options(3).

Nanotechnology in gene delivery

Nanotechnology has revolutionized the field of gene therapy by providing advanced tools for delivering therapeutic genes to specific cells and tissues. At the nanoscale, materials exhibit unique properties that can be harnessed to encapsulate and protect genetic material, control its release, and target its delivery with unprecedented precision(4). Nanocarriers, such as nanoparticles, liposomes, and dendrimers, can be engineered to overcome biological barriers, enhance cellular uptake, and improve the stability of genetic therapies. This nanoscale approach to gene delivery not only increases the efficiency of gene transfer but also minimizes off-target effects, thereby enhancing the safety profile of gene therapies. As nanotechnology continues to evolve, it is paving the way for more sophisticated and personalized gene therapy applications(5).

Importance of targeted gene delivery in enhancing the efficacy and safety of gene therapy

Targeted gene delivery is a critical aspect of gene therapy that ensures therapeutic genes reach their intended cells or tissues without affecting others, thereby maximizing therapeutic efficacy and minimizing side effects. This precision is crucial, especially in complex diseases like cancer, where it's essential to distinguish between healthy and diseased cells(6). Targeted delivery systems can recognize specific cell markers, facilitating the selective introduction of genetic material into diseased cells while sparing healthy ones. This targeted approach not only enhances the effectiveness of gene therapy but also significantly reduces the risk of unintended interactions, which can lead to adverse effects. As research progresses, the ability to target genes more accurately will be pivotal in expanding the therapeutic potential of gene therapy across a broader range of conditions(7).

Objectives and scope of the review

The objective of this review is to provide a comprehensive overview of the current advances, challenges, and future directions in nano targeted gene delivery. By exploring the integration of nanotechnology with gene therapy, this review aims to elucidate how nanoengineering advances are enhancing the precision, efficacy, and safety of gene delivery methods(8). The scope includes an examination of the various nanocarriers and targeting strategies employed, an analysis of the current clinical and preclinical applications, and a discussion of the technological and biological hurdles facing the field. Additionally, the review will explore future prospects, highlighting emerging trends and potential interdisciplinary collaborations that could drive the next wave of innovations in nano targeted gene delivery(9). Through this, the review intends to provide valuable insights for researchers, clinicians, and policymakers involved in the development and application of these transformative medical technologies(10).

Advances in Nano Targeted Gene Delivery

Summary of recent advancements in nanotechnology for gene delivery

Recent advancements in nanotechnology for gene delivery have centered on the development of innovative nanocarriers that offer enhanced delivery efficiency, improved targeting capabilities, and increased gene expression control. Scientists have engineered nanoparticles with stimuli-responsive features, allowing them to release their



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genetic cargo in response to specific cellular or tissue environments(11). There's also significant progress in designing multifunctional nanosystems that integrate diagnostic and therapeutic functions, enabling real-time monitoring of gene delivery and expression. Advances in surface engineering have led to the development of nanocarriers with improved biocompatibility and reduced immunogenicity, facilitating their safe use in clinical applications(12). Additionally, the integration of nanotechnology with CRISPR-Cas systems represents a cutting-edge advancement, offering precise and efficient gene editing capabilities that hold promise for correcting genetic disorders at their source.

Description of various nanomaterials used for targeted gene delivery

Liposomes, spherical vesicles consisting of one or more phospholipid bilayers, have been extensively used for gene delivery due to their biocompatibility and ability to encapsulate both hydrophilic and hydrophobic substances. Dendrimers, highly branched, star-shaped macromolecules, offer a high degree of surface functionality that can be tailored for targeted delivery, enabling them to bind to specific cell surface receptors(13). Nanoparticles, including metallic nanoparticles, polymeric nanoparticles, and solid lipid nanoparticles, provide versatile platforms for gene delivery, with customizable sizes, shapes, and surface properties to enhance cellular uptake and targeting. Quantum dots and carbon nanotubes have also been explored for their unique optical and electrical properties, respectively, contributing to the broad spectrum of nanomaterials available for targeted gene delivery applications.(14)

Mechanisms of targeted gene delivery at the cellular and molecular levels

Targeted gene delivery at the cellular and molecular levels involves several key mechanisms. Ligand-receptor interactions are commonly used, where the surface of nanocarriers is modified with ligands that specifically bind to receptors on target cells, enhancing uptake via receptor-mediated endocytosis. Another approach is the use of cell-penetrating peptides that facilitate the direct translocation of genetic material across the cell membrane.(15) Additionally, environmentally responsive nanocarriers can alter their behavior in response to specific cellular or tissue stimuli, such as pH or enzyme presence, to enhance gene release at the target site. These mechanisms ensure that the genetic material is not only delivered efficiently to the target cells but is also released in a controlled manner, optimizing the gene therapy's therapeutic effect.

Highlighting key studies and breakthroughs in the field

Key studies in nano targeted gene delivery have demonstrated significant breakthroughs, such as the successful use of lipid nanoparticles to deliver mRNA in COVID-19 vaccines, showcasing the potential of nanotechnology in rapid vaccine development. Another notable breakthrough is the use of polymer-based nanoparticles to deliver CRISPR-Cas9 components, enabling precise gene editing in vivo.(16) Studies involving the use of magnetic nanoparticles for targeted gene delivery under the guidance of external magnetic fields have opened new avenues for localized gene therapy. Additionally, the development of biodegradable nanocarriers addresses long-standing concerns regarding the long-term safety and environmental impact of nanomaterials. These studies not only highlight the potential of nano targeted gene delivery in treating a variety of diseases but also underscore the field's rapid evolution and its readiness to address emerging healthcare challenges.(17)

Applications of Nano Targeted Gene Delivery

Therapeutic applications in various diseases such as cancer, genetic disorders, and infectious diseases

Nano targeted gene delivery has revolutionized the treatment landscape for several challenging diseases. In cancer therapy, nanocarriers are designed to target tumor cells selectively, reducing the systemic side effects of conventional chemotherapy and increasing the therapeutic efficacy of gene-based treatments(18). For genetic disorders, such as cystic fibrosis or muscular dystrophy, nano targeted delivery systems offer a promising approach to correct defective genes directly within the affected tissues. Infectious diseases also benefit from this technology, where targeted gene delivery can be used to enhance the immune response against pathogens or disrupt the genetic machinery of viruses and bacteria, providing a novel approach to treatment beyond traditional vaccines and antimicrobials(19).



**Haricharan et al.,****Role in personalized medicine and tissue engineering**

In personalized medicine, nano targeted gene delivery systems enable the tailoring of therapies to individual patients based on their genetic makeup, improving treatment outcomes and minimizing adverse effects(20). This precision approach ensures that patients receive the most effective gene therapies based on their unique genetic profiles and disease characteristics. In tissue engineering, nanotechnology facilitates the delivery of genes that promote tissue regeneration and repair, offering innovative solutions for regenerative medicine. By precisely controlling the release and localization of therapeutic genes, nano targeted delivery systems can significantly enhance tissue engineering strategies, contributing to the development of engineered tissues and organs with improved functionality and integration with the host(21).

Discussion on the clinical trials and approved therapies using nano targeted gene delivery

Several clinical trials have underscored the potential of nano targeted gene delivery in various therapeutic areas. For example, clinical trials involving nanoparticle-mediated delivery of nucleic acids have shown promise in treating genetic diseases and cancers. One of the landmark successes in the field is the use of lipid nanoparticles in the delivery of mRNA vaccines for COVID-19, representing one of the first widespread clinical applications of nano targeted gene delivery(22). Additionally, there are ongoing trials exploring the efficacy of nanoparticle systems in delivering gene-editing tools like CRISPR-Cas9 to treat inherited genetic disorders. Although the number of approved nano targeted gene therapies is still limited, the successful outcomes of these trials indicate a promising future for the approval and clinical use of such advanced therapeutic modalities, potentially transforming the treatment paradigm for many incurable and chronic diseases.

Challenges in Nano Targeted Gene Delivery**Technical challenges in design and manufacturing of nanocarriers**

The design and manufacturing of nanocarriers for targeted gene delivery pose significant technical challenges due to the complex requirements for efficacy, safety, and stability. Creating nanocarriers with precise size, shape, and surface characteristics is crucial for their biological function and distribution in the body. Ensuring uniformity and scalability in production is another major challenge, as inconsistencies can affect the clinical outcomes and feasibility of large-scale manufacturing(23). Additionally, the stability of nanocarriers during storage and upon administration needs to be meticulously optimized to prevent premature release or degradation of the encapsulated genetic material. Addressing these technical challenges requires advanced fabrication techniques, thorough characterization, and robust quality control measures to ensure the consistent performance and reliability of nanocarriers in clinical settings.

Biological challenges such as immune response, targeting accuracy, and gene expression control

Biological challenges are significant in the development of nano targeted gene delivery systems. The immune response to nanocarriers can lead to rapid clearance or potential adverse reactions, which necessitates the design of stealthy nanoparticles that can evade the immune system. Achieving high targeting accuracy to ensure that the gene therapy reaches the intended cells or tissues without affecting healthy ones is another critical challenge(24). This requires the development of sophisticated targeting ligands and the understanding of the dynamic biological environment in which these nanocarriers operate. Furthermore, controlling the expression of the delivered gene is paramount to ensure therapeutic efficacy and prevent potential off-target effects or gene overexpression, which necessitates the incorporation of regulatory elements and controlled release mechanisms in the design of nanocarriers(25).

Ethical, regulatory, and safety concerns

Ethical and regulatory challenges are inherent in the development and implementation of nano targeted gene delivery systems. The long-term safety of nanocarriers, potential off-target effects, and the implications of gene editing are major ethical concerns that need to be addressed. Regulatory bodies are tasked with establishing guidelines and approval processes that ensure the safety and efficacy of these advanced therapeutic technologies(26). The regulatory landscape must adapt to the rapid advancements in nanotechnology and gene therapy, ensuring that





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these innovations benefit patients while upholding ethical standards(27). Additionally, there is a need for comprehensive safety evaluations, including the assessment of long-term effects and the potential impact of nanoparticles on the environment. Addressing these ethical, regulatory, and safety concerns is crucial for maintaining public trust and facilitating the successful integration of nano targeted gene delivery into clinical practice.

Future Direction

Emerging trends and technologies in nano targeted gene delivery

The future of nano targeted gene delivery is poised to be shaped by several emerging trends and technologies. One significant trend is the development of smart nanocarriers that can respond to specific stimuli (e.g., pH, temperature, enzymes) present in the disease microenvironment, enabling precise control over gene release(28). Another promising area is the use of exosome-based delivery systems, leveraging nature's own method of intercellular communication to transport genetic material. There's also increasing interest in developing hybrid nanosystems that combine organic and inorganic materials to leverage the advantages of each, enhancing targeting capabilities and biocompatibility(29). Furthermore, advancements in 3D bioprinting technology are expected to play a crucial role in creating complex tissue models for testing and optimizing nano targeted gene delivery systems.

The potential of integrating AI and machine learning for the design and optimization of nanocarriers:

Artificial intelligence (AI) and machine learning (ML) offer transformative potential for the design and optimization of nanocarriers in gene delivery. These technologies can analyze vast datasets to predict the behavior and efficacy of nanocarriers in biological systems, speeding up the design process and identifying optimal formulations with improved precision(30). AI can also facilitate the modeling of nanocarrier interactions with cells and biological barriers, enhancing our understanding of their biodistribution and pharmacokinetics. Furthermore, machine learning algorithms can assist in identifying novel biomaterials and surface modifications to improve the targeting and biocompatibility of nanocarriers, ultimately leading to more effective and safer gene delivery systems(31).

Interdisciplinary approaches involving material science, biology, and engineering

The future advancements in nano targeted gene delivery will increasingly rely on interdisciplinary approaches that merge insights and methodologies from material science, biology, and engineering. Material scientists contribute by designing and synthesizing novel nanomaterials with tailored properties for gene delivery(32). Biologists play a crucial role in understanding the cellular and molecular mechanisms that underpin the interaction between nanocarriers and biological systems. Engineers apply principles of nanotechnology and biotechnology to develop scalable and reproducible manufacturing processes for nanocarriers(33). This collaborative approach fosters innovation and accelerates the translation of nano targeted gene delivery systems from the laboratory to clinical applications, offering new solutions for challenging medical conditions and opening new avenues for personalized medicine(34).

CONCLUSION

Summarize the current status of nano targeted gene delivery

The field of nano targeted gene delivery is at a promising juncture, having made significant strides in addressing complex medical challenges. Advancements in nanotechnology have enabled the development of sophisticated nanocarriers capable of delivering genetic material with unprecedented precision and efficiency. These innovations have found applications across various domains, including cancer therapy, genetic disorders, and infectious diseases, demonstrating potential to fundamentally transform treatment paradigms. Despite these advances, the field is still evolving, with ongoing research focused on enhancing the specificity, safety, and efficacy of gene delivery systems.



**Haricharan et al.,****Reiterate the importance of overcoming current challenges for future advancements**

To realize the full potential of nano targeted gene delivery, it is imperative to address the existing technical, biological, and regulatory challenges. Overcoming technical hurdles related to the design, manufacturing, and characterization of nanocarriers is crucial for ensuring their performance and reproducibility. Addressing biological challenges, such as immune response, targeting accuracy, and gene expression control, is essential for enhancing the efficacy and safety of gene therapies. Additionally, navigating ethical and regulatory landscapes is vital to ensure that these advanced technologies are safely and effectively translated into clinical practice, benefiting patients while adhering to the highest standards of medical ethics.

Final thoughts on the potential impact of these advancements on healthcare

The advancements in nano targeted gene delivery hold transformative potential for healthcare, offering new avenues for the treatment of diseases that were once considered untreatable. By enabling precise and efficient delivery of therapeutic genes, this technology has the potential to revolutionize personalized medicine, providing treatments tailored to individual genetic profiles. Moreover, the integration of emerging technologies like AI and interdisciplinary approaches will further accelerate the development of innovative solutions, enhancing patient outcomes and healthcare efficiency. As the field continues to evolve, it is poised to play a pivotal role in shaping the future of medical treatments, ultimately leading to a new era in healthcare where gene therapy becomes a cornerstone of medical practice.

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Table 1: Nanomaterials Used in Nano Targeted Gene Delivery

Nanomaterial	Properties	Applications
Liposomes	Biocompatible vesicles; encapsulate hydrophilic and hydrophobic substances	Widely used in gene delivery for various diseases
Dendrimers	Highly branched, star-shaped macromolecules with surface functionality	Targeted gene delivery to specific cell types
Nanoparticles	Customizable size, shape, and surface properties; includes metallic, polymeric, and solid lipid nanoparticles	Versatile platforms for gene delivery, enhancing cellular uptake and targeting
Quantum Dots	Possess unique optical properties	Studied for targeted gene delivery and imaging
Carbon Nanotubes	Known for their unique electrical properties	Investigated for their potential in gene delivery

Table 2: Challenges and Future Directions in Nano Targeted Gene Delivery

Challenge/Future Direction	Description
Technical Challenges	Includes issues in design, manufacturing, and characterization of nanocarriers, needing advanced techniques for consistent performance.
Biological Challenges	Encompasses immune response, targeting accuracy, gene expression control, necessitating sophisticated targeting ligands and understanding of biological interactions.
Ethical and Regulatory Considerations	Involves addressing long-term safety, potential off-target effects, and compliance with evolving regulatory standards.
Integration of AI and Machine Learning	Utilizing AI and ML for optimizing nanocarrier design, predicting behavior, and enhancing the efficiency of gene delivery systems.
Interdisciplinary Approaches	Combining insights from material science, biology, and engineering to innovate and accelerate the translation of nano targeted gene delivery systems into clinical applications.





A Deep Learning Framework for Medical Imaging Precision Liver Tumor

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ABSTRACT

Surgeons' planning depends on precisely differentiating between hepatic and liver cancers in CT scans. Manual liver tumor extraction from CT scans is difficult, time-consuming, and dependent on clinical knowledge, though, given the blurry boundaries and low contrast between healthy and malignant tissue. Automated means to classify liver and hepatic cancers into different categories will help to improve surgical planning, treatment, and follow-up care. This work offers a user-friendly method for locating malignancies in the liver on CT scans. The suggested system makes use of region-based segmentation methods and ResUNet architecture. The procedure starts with portions of the liver being divided and subsequently finds malignancies inside the hepatic capsule. While region-level segmentation significantly enhances the general quality of the segmentation map, ResUNet—a network trained on annotated CT scans—accurately predicts the location of liver tissue. The publicly accessible 3D-IRCADb dataset is used in evaluation of the model. The Dice coefficient and volumetric overlap error (VOE) assessed the suggested method's performance. For the tumor, the ResUNet model scored 0.96; for the liver, it scored 0.97. It also dropped the VOE for the tumor to 0.615 and for the liver to 1.90. The ResUNet model suggested in this work shows better performance than before described techniques. The accuracy and output quality are much improved by using U-Net into the building of the model.

Keywords: blurry boundaries, techniques, VOE, cancers, ResUNet, architecture.



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INTRODUCTION

According to the World Health Organization (WHO), liver tumors are one of the worst types of cancer. Each year, they cause about 8.5 million new cases and almost 7 million deaths. The American Cancer Society projects that 41,210 fresh instances of primary liver cancer will arise in the United States in 2023, leading to 29,380 fatalities [1]. These numbers point to an increasing incidence of liver cancer in general. One often utilized method for liver cancer detection and liver segmentation is computed tomography (CT) imaging [2]. Still, manually spotting liver tumors from CT scans is a time-consuming task mostly dependent on operator skill and expertise. Thus, enabling doctors to precisely identify liver cancer depends on the development of a competent computer-aided diagnosis (CAD) system. Comprising a right lobe and a left lobe, the liver links itself to the gallbladder, pancreas, and intestines. Two key causes of its cancer susceptibility are the high density of liver cells and the possibility for malignant cells to spread from other body parts.

Figure 1 shows patients with liver cancer broken out by stage. Automatic liver tumor segmentation is used in medical imaging is a method used to precisely identify, classify, and isolate liver tissue from surrounding tissues, so separating cancerous from healthy cells. Training deep learning models on a vast collection of precisely labeled liver and tumor segments, annotated by medical professionals including doctors and radiologists, is an effective strategy. These models can be included into software or computer-aided diagnosis systems following exhaustive testing and validation. Without depending on medical professionals, developing a precise and efficient liver tumor segmentation algorithm can result in major savings in both cost and time as well as the possible to save lives [3]. Two key types of current deep learning segmentation methods are 3D-FCN, which employs 3D convolutions instead of the conventional 2D convolutions [4] and fully convolutional networks (FCN), which comprise U-Net, multi-channel FCN, and VGG-based FCN. An individual's life expectancy is largely influenced by the location of cancer inside the body (as depicted in Figure 1) and determines treatment choices. Usually referred to as stage 1, cancer is often categorized as localized when it stays limited to its original place within the body. Should the cancer have progressed to other areas of the body, it is classified as regional or distant. Early liver cancer diagnosis greatly increases the likelihood of survival five years following diagnosis [5]. This localized stage of diagnosis accounts for 44.6 percent of liver and intrahepatic bile duct cancers.

LITERATURE REVIEW

Deep learning (DL) and medical imaging have had notable developments recently [6–8]. Extensive studies have concentrated on employing medical imaging methods coupled with deep learning models including convolutional layers to detect cancer or tumors. Researchers Sharma et al. [9] used machine learning (ML) techniques called random forest (RF) and k-nearest neighbor (k-NN) to figure out which women were most likely to get breast cancer. In a different study, Khari et al. [10] used CNNs to find brain tumors. [11] examined several machine learning methods closely for brain tumor detection and classification. Tumours are sometimes split in surgical operations into smaller pieces. Monitoring treatment progress over time depends on accurate knowledge about the location and shape of the tumor, which will help doctors to maximize therapy methods for several phases of liver cancer. Liver cancer can be broken up for study into several sections. Roy et al. [12] suggested a method to distinguish liver cancer nuclei by means of histomorphology scans and edge detection Anter et al. [13] investigated extensively the use of machine learning (ML) methods to enhance the identification of liver tumors. Another work [14] showed that deep learning can cluster and categorize liver cancers rather successfully. Using common image processing, computer vision, and machine learning methods, CT picture features like pixel intensities, color, texture, tumor size, and shape are put together [15]. These traits are then used using a classifier technique to find segmentation pictures. CNNs vary between high-level and low-level characteristics of CT images by means of several convolutional layers [16, 17]. Crucially, the creation of a specific Computer-Aided Design (CAD) system for liver cancer detection calls for [18]. There are several deep learning models at hand to help with this work. Figure 2 offers a summary of the approaches



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covered in different research projects. ML [19–21], clustering, graph-cut, and other semi-automatic liver tumor segmentation models [22–24] have been extensively studied.

APPROACH

This work explain a method based on systematic deep learning to effectively differentiate hepatic malignancies from liver tissue in CT scan pictures. The research turned out numerous important results: By increasing the amount of image samples, I. Data augmentation methods include rotation, flipping, zooming, cropping, and color corrections provide variety into the dataset. II. Reducing the kernel count in every convolution layer greatly speeds up the learning process of the network, therefore enabling its more effective use of the given input. III. The method discards frames without tumor pixels and keeps those with all the necessary information, hence improving tumor detection in CT images. This procedure helps to reduce the performance difference among students from many backgrounds. Figure 3 shows the suggested architectural sequential flow. The structure uses these guidelines: Raw CT scan images make up the dataset; these are filtered and standardized during pre-processing to eliminate extraneous noise. IV. ReLU activation function followed by batch normalisation (BN) is applied during encoding process. Semantic meaning of the image is captured by the encoder in segmentation. While max-pooling shrinks the size of feature maps through downsampling, convolutional layers offer thorough information about the background. Following the convolution and ReLU activation layers are introduced max-pooling layers. Between the encoder and decoder, this intermediary layer forms a bottleneck. Considered the bottleneck layer, it comprises two convolutional layers after a batch normalisation layer. This layer mostly serves to find and extract intricate visual elements from the image. Situated halfway between the encoder and decoder paths, it lets the network mix finely-grained geographical features with semantically rich information.

The decoder consists in four upsampling and decoding phases. The deconvolution or up-convolution layers in these blocks bring back feature maps to their original sizes and provide additional spatial information about the segmented image. There are two up-convolution layers in each stage, with layers from the encoder scattered throughout the expanding path layers. The background is separated from the liver and tumor using a sigmoid activation function in final stage. Figure 5 shows a flowchart of the suggested method including pictures.

Instructed and Evaluated The Binary Deep Neural Network (DNN) Classifier

The ResUNet model is made up of an input layer, three hidden layers for both the contraction and expansion paths, and an output layer. The output layer contains two nodes, but the input layer has 26 nodes. The three secret levels have 20, 30, and 15 nodes, respectively. Each neuron in the network is first assigned arbitrary weights and biases. The Rectified Linear Unit (ReLU) activation function transports gradients from each neuron to the hidden layers. Assume X to be the input image matrix; W the weight matrix; B the bias matrix. Every neuron then generates an output signal expressed as a matrix. ReLU activation function defines the maximum of 0 and the input value (Y), therefore determining the output of a neuron. L2 regularization—adding a term of $\frac{1}{2} \mu w^2$ to every computed network weight—is used to prevent overfitting. This work employs cross-entropy as the loss function for the binary classification challenge. The network is trained using the stochastic gradient descent (SGD) optimizer, with backpropagation used to change the weights. The process of instruction go on until the mistake is reduced. Then, the trained deep neural network (DNN) classifier's weights and parameters are stored to assess the network on test data.

Data Set

CT scan pictures [25] carefully annotated by medical experts to distinguish and identify different anatomical components make up the 3D-IRCADb database. Three-dimensional computed tomography (CT) scans of ten male and ten female livers are in the collection. Line spacing ranges from 0.57 to 0.87 mm; the slices are 1.6 to 4 mm apart. Throughout the acquisition of these CT scans, the subjects were in the "inhaling" posture. Ten scans make up the training set of data; five scans constitute the test set. Trained on photos of different sizes, the model shows better performance on 512x512 images than lower-resolution ones with a 2% and 7% increase in accuracy correspondingly separating liver tissue from malignancies. Down sampling lowers tumor segmentation's accuracy. Consequently,



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images with a 512x 512 resolution train and test the models. Given their identical resolution, the accuracy is much enhanced from both datasets.

FINDINGS AND ANALYSIS

The outcomes of modeling and applying the grading and segmentation techniques are covered in this chapter. Specifically a 64-bit i5 CPU with a clock speed of 3.6 GHz and 8 GB of RAM, a Python application was used to replicate a computer system running Windows 10. Two different machine learning techniques—Support Vector Machine (SVM) and Deep Neural Network (DNN)—had to be used in the classification challenge. We examined and contrasted the outputs of various algorithms. We assessed each pixel class in the tumor and liver areas using accuracy (AC), sensitivity (SN), and specificity (SP). Using volumetric overlap error (VOE), dice similarity coefficient (DSC), and valid dice coefficient (VDC), the proposed approaches are evaluated in relation to past used ones.

The confusion matrix in Figure 6 illustrates ResUNet's liver and non-liver pixel identification accuracy and errors. Figure 7 illustrates ResUNet's tumor segmentation confusion matrix. The confusion matrices represent the percentage of correctly categorized pixels in a class (compared to the total number). Performance of the model was assessed just using average symmetric surface distance, relative volume difference, VOE, and DSC criteria. A more exact representation of the segmentation data is obtained using the Dice coefficient; a higher value denotes a best result. As Table 1 shows, we effectively divided the liver using ResUNet. As Table 2 shows, we effectively segregated tumors using our suggested ResUNet model. Random data from the test set is used to test the model. Figure 8(a) demonstrates a true value accuracy of 99.4% and 98.1%. The liver that is anticipated can be observed in Figure 8(b). The provided text illustrates a random sample of the validation data that was employed to evaluate the model. Figure 9(a) displays a random sample with a precision of 99.8%, a True Value Accuracy of 93.8%, and a die coefficient of around 95.2%. The anticipated expansion is depicted in Figure 9(b). Support Vector Machines (SVM) and Deep Neural Networks (DNN) are the two most common approaches for classifying tumors.

CONCLUSION

Using the ResUNet model, which requires a far smaller volume of training data than U-Net, this work offers a two-tier method to differentiate between liver and tumors. Both of which are well used techniques, the suggested strategy beats the SVM classifier and the DNN classifier. This work evaluates the proposed ResUNet model using the publicly accessible 3D-IRCADb dataset. The efficacy of the approaches is assessed using performance criteria including Volumetric Overlap Error (VOE) and Dice Similarity Coefficient (DSC). Regarding both measures, the recommended approach always produces better results as time passes. Moreover, the U-net design ensures that the final image preserves the same degree of quality and exact proportions as the original input picture. The approach used in this work eliminates the need for any later data modification to improve the quality of the outcomes. One can improve and test the model using different specimens. Through some changes, the suggested approach implementation can be applied in related medical situations. Many datasets can be combined for analysis should future computational capability be suitable. Furthermore, this approach can be used to separate several approaches related to organs such lungs, kidneys, brain, etc., as well as different modalities of medical imaging including ultrasounds, MRI, etc.

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Table 1. The Experimental outcomes for liver segmentation with the ResUNet model

S.No	Evaluation Metrics	ResU-Net Network
1	DSC	0.893
2	Accuracy	0.97
3	Precision	0.950
4	Specificity	0.957
5	VOE	13.15
6	RVD	7.23





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Table 2. Training and validation dice coefficient (F1 score) findings for the ResUNet liver segmentation model

Epoch	Epoch dice coefficient (F1 Score)	Valid dice coefficient(F1 Score)
1	0.8695	0.8931
2	0.9009	0.843
3	0.9252	0.9053
4	0.9348	0.0208
5	0.9472	0.9398
6	0.9583	0.9168
7	0.9653	0.9332
8	0.9692	0.9549
9	0.9735	0.9737
10	0.9854	0.9852
11	0.9958	0.9976

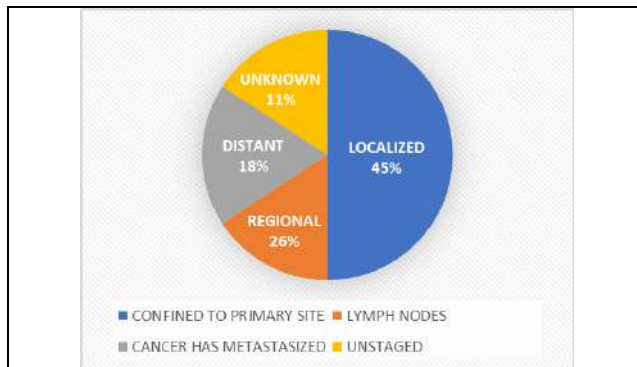


Figure 1. Distribution of liver cancer cases by stages

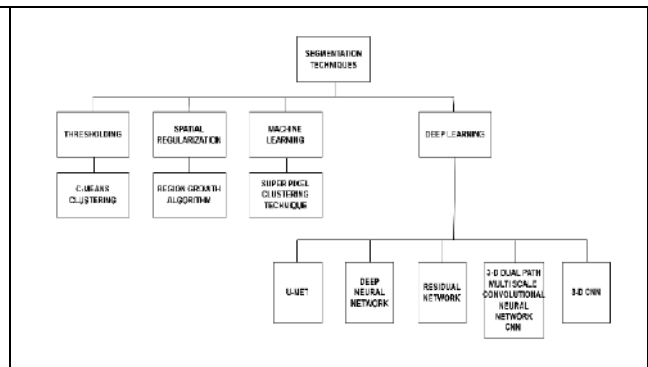


Figure 2: Strategies for Liver Cancer Segmentation: A Review of Relevant Literature

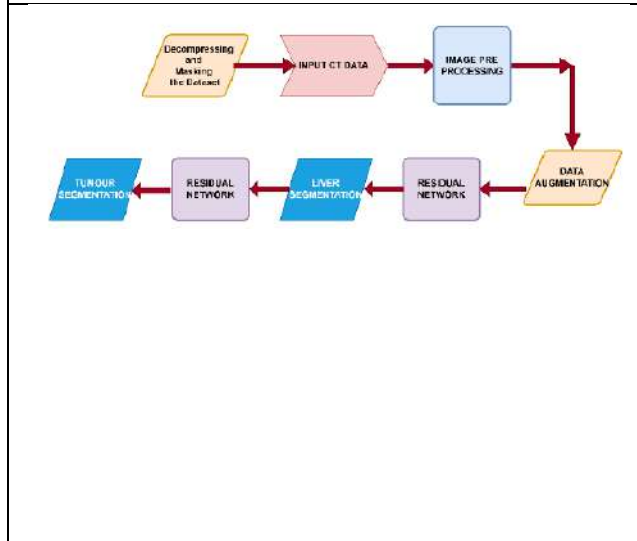


Figure 3. suggestions for a method to separate the liver and tumors

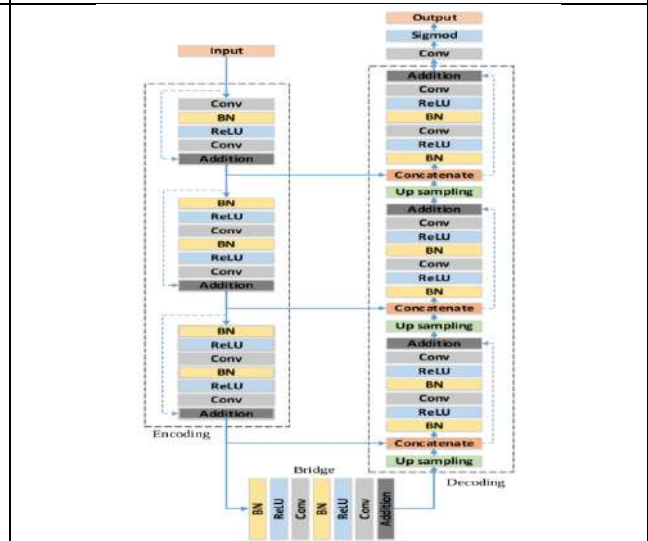


Figure 4: Residual UNET Architecture





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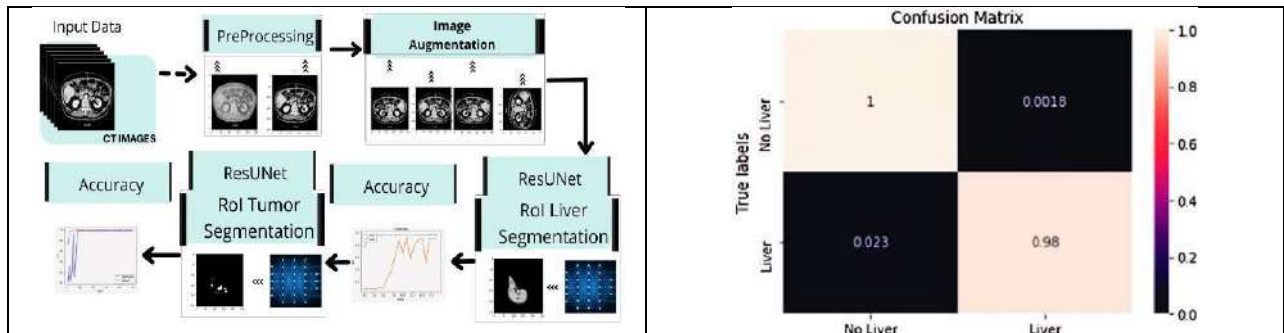


Figure 5: Proposed Method for Liver Tumour And Liver Segmentation

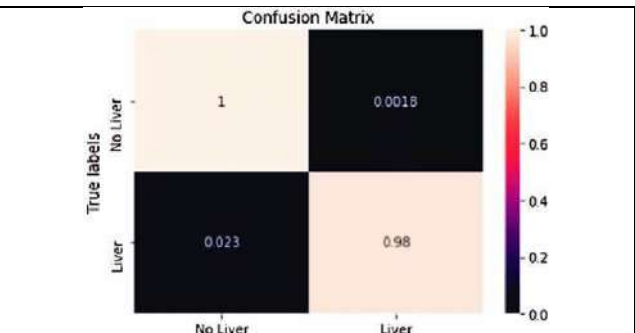


Figure 6. Confusion Matrix After Liver

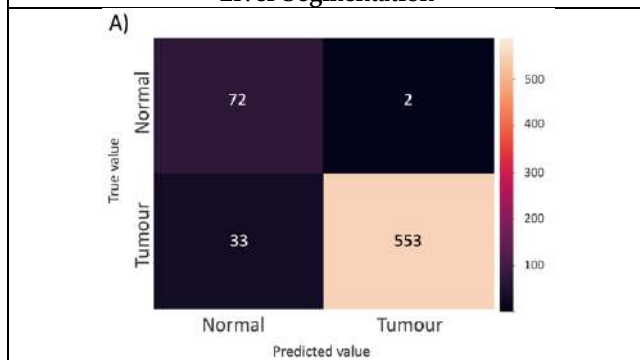


Figure 7. Confusion matrix for tumor based on the proposed model

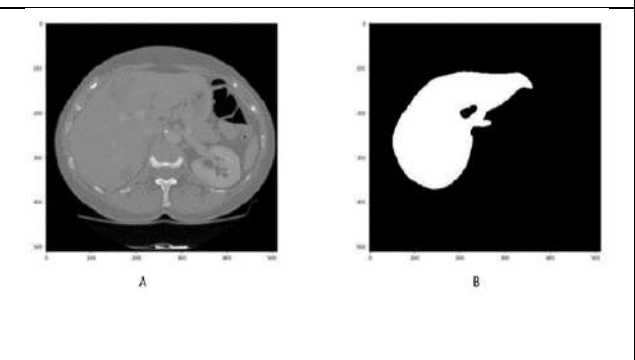


Figure 8. (a) A randomly selected image from the dataset (b) The liver that has been isolated from the selected image

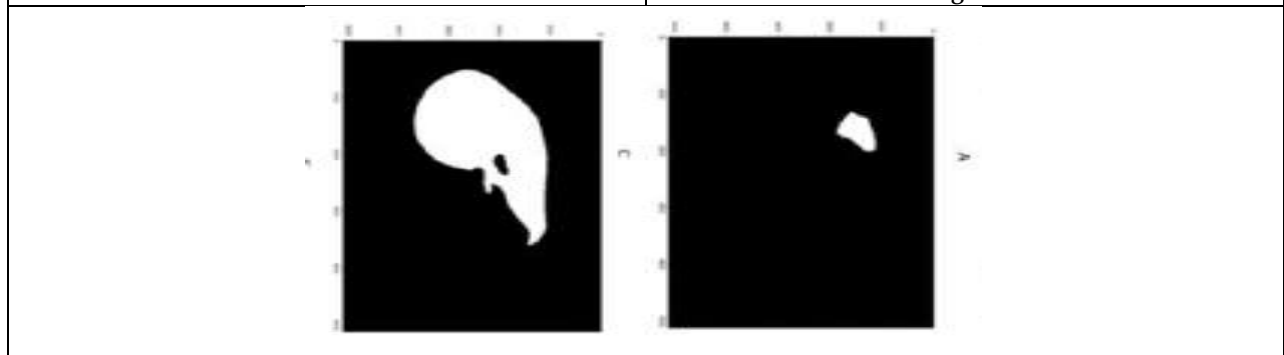


Figure 9. (a) An image randomly selected from the dataset. (b) The tumor that has been isolated and identified from the selected sample.





AI International Film Festival [AIIFF] can Foster Entrepreneurship and Creative Innovations in Film Industry

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ABSTRACT

This paper explores the role of AI in film festivals and how such technologies or plat forms democratize the film making process for independent artists and startups, hence breaking traditional barriers. Among the main challenges filmmakers face, other than securing funds, time management, and technical resources from pre-production to post- production final editing, is the hope for a profitable ROI by the independent producer. AI Festival platforms help film makers create unique visuals and animations despite the restrictive budget of a conventional film and serve as a no-frills but competitive product to stay in the market. These festivals give an opportunity for upcoming filmmakers to showcase their work and bring them into the limelight. For independent filmmakers, receiving an award at an international festival may give them a chance to realize their dream of perfecting the craft of AI film making by creating more innovative projects. Different films with different styles will testify to the grand canvass on which storytelling has been painted, allowing filmmakers to experiment and innovate, bringing artists, technologists, and industry leaders together to leverage the creative synergies between human imagination and AI. Events such as business schools' AI Film Festivals bridge the gap by allowing the artists and AI specialists to collaborate and understand the know-how for new creative alliances and business opportunities. This kind of film festival enables filmmakers to also acquire business skills in developing the pitch for one's ideas, investment, branding, and marketing projects. It is quite common for many startups and production companies to go through a transition from that story idea on the back of the sketch to a first version on a shoestring budget. Equally, it prepares the film maker aspirants with the necessary skills to turn their creative vision in to a





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Successful business venture. In short, AI film festivals create access to film making, uncover new talent, inspire creativity, encourage collaboration, and cultivate future creative entrepreneurs and content communities.

Keywords: Data collection; Innovation, Experimentation; Talent Showcase; Access.

INTRODUCTION

Artificial Intelligence enhances the art of storytelling in short films greatly by applying different advanced techniques and tools that make the entire creative process faster, efficient, and packed with value in stories. AI technologies currently help filmmakers make the very first steps in developing ideas and surmounting creative obstacles. For example, OpenAI could suggest names of characters, plots, and dialogues that could constitute the premise of original stories. Indeed, a fast-thinking AI can create multiple ideas connected with certain criteria much faster than humans can produce, which allows filmmakers to explore more variations of ideas in less time.

Improvement in Visuals and Audio: AI tools like Midjourney and Runway ML can help creators with stunning visuals and pictures. These tools are capable of generating concept art or entire sequences that might be helpful in better visualization for the creators.

Voice overs and Sound Design: AI helps to temporarily voice over and create other vital sound elements in films. Services such as Eleven Labs provide high-quality audio that is helpful in short films to enhance the storytelling experience in all aspects of filmmaking.

Editing and Animation: With the help of AI, editing has become somewhat easier because it automates all the mundane tasks such as transitions between scenes and image stabilization.

Emotional Engagement: Through AI, stories can be built emotionally to resonate with viewers. The tools analyze viewer preferences and trends to help filmmakers create narratives that emotionally engage the audience.

METHODOLOGY: LOGICAL PROCESSING

NAVRASA encompasses the nine fundamental emotions that exist in human life. By integrating AI technology at different levels of filmmaking, we were able to successfully arrange a festival featuring the business schools of different institutions.

EARLY PLANNING PHASE

AI greatly enhances the early planning phase by managing and automating many complex facets of this process, allowing a much greater level of creativity. The following are the major roles of AI for filmmakers in this stage:

Automated Script Analysis: AI, through platforms like Filmustage, uses machine learning to auto-analyze scripts. What earlier needed several hours of manual work now only takes a few minutes as AI breaks down the script and organizes all elements involving cast, locations, and props.

Potential Risks Identification: AI helps filmmakers make out any potential threats to their scripts and production plans. For example, Filmustage AI Labs Analysis scan for vulnerabilities, such as safety concerns or copyright issues, and come up with ways to diminish these risks.

More Effective Team Collaboration: AI-driven platforms ensure better collaboration among the team members by





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hosting all pre-production aspects on a single interface: script analysis, filming scheduling, and budget management.

Lessons from Scripts and Audience: The extraction of vital data-everything from emotional journeys to the narrative structure-is heavily reliant on analytic AI tools. With integrated NLP, filmmakers now can tune their scripts for crowd reactions expected hence trying to involve audiences even more in telling the story.

AI Assists in Actor Selection: It does so by assessing their performance and character to best decide if they would be good enough for the chosen role. The use of tools like Casting Droid or Largo AI helps in discovering newer talent and making diverse casts, ultimately improving the quality of the film.

Location Suggestions: AI speeds up location scouting, suggesting places that fit the scenery described in the script.

Storyboard and Visualization: AI-powered storyboard generators let filmmakers visualize scenes and their compositions in minimal time. Using D-ID and Cuebric, filmmakers can rapidly see scenes on screen to help them make quick decisions over shot and composition planning.

Production phase

Artificial Intelligence has transformed film production by introducing efficiency, creativity, and quality. Its major roles in this critical stage of filmmaking are pegged on the following aspects:

Efficient Shooting Schedules: AI-powered tools like Scenechronize and Celtx use historical production data, weather forecasts, and equipment availability to optimally plan a shoot. By anticipating probable delays, such platforms adjust timelines in tandem with such expectations.

Automation of camera operations: Traditional methods of film shooting are now replaced by AI-operated cameras and robotic cinematography devices. Companies like ARRI and RED are leading the development of highly technical cameras, which could automate aspects such as framing, focus, and exposure. Difficult camera movements can be done with a small crew using this technology, hence reducing production costs.

Better Cinematography: Filmmakers can create much better visuals through the use of AI- powered techniques, with much less effort. AI helps in innovative storytelling by enhancing camera movement and shot composition.

Real-time Performance Analysis: With tools such as Analysis Morph Cast and Affectiva, actors are monitored in real time for their facial expressions and emotions while filming. This serves as a way to deeply understand and build more character-driven stories.

Continuity Monitoring: AI tools like Filmstuge help a continuity supervisor in consistently reproducing scenes and correctly placing props throughout the shoot.

Predictive Analytics for Resource Allocation: By looking at data from different points related to the production process, such as cast schedules, location availability, and equipment logistics, AI makes good predictions of resource needs and allocates them appropriately.

Post-Production

Automated Editing: AI algorithms can sift through a huge number of footage pieces to select the best scenes, close-ups, and reactions. This can make editing quite easier and faster. Softwares like Adobe Sensei handle jobs like scene segmentation and prioritizing color grading.





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RESULTS

Assess the research on comparing AI film production with traditional film production:

Pre-Production AI Film Production: Writing the Script and Planning the Story: Artificial Intelligence Tools even analyze scripts to determine the emotional intensity, character development, and appeal the characters will have with an audience. Filmmakers receive insights on which projects to base their work. AI-driven platforms, like ScriptBook, predict audience reactions and box office success by informing decisions.

Casting and Location Search: AI algorithms find ideal actors' past performance and audience demographic matches for more diverse casting.

Traditional Film Production:

Human Creativity: It finds its basis in human creativity and experience. There is much brainstorming and discussions among filmmakers, which forms a story supported by the relationship between characters.

Production Stage

AI Film Production - Automated Cinematography: Cameras equipped with AI can automate a lot of tasks, such as focusing and exposure, to ensure uniform shots and footage during complex camera movements, without having to involve many crew members. Other tools like Scenechronize optimize shooting schedules based on historical data and current conditions.

Performance Evaluation: AI can assess the actors' facial expressions when filming a scene and advise the director on where performance improvements are needed to sustain the emotions across different scenes.

Post-Production:

Such special visual effects, with the power of AI, can be created in a photorealistic way in a far more effective manner, removing the heavy time and manpower required to achieve these special effects. This allows filmmakers to work with larger-scale scenes that were not possible using earlier VFX techniques.

Artistic Editing in Traditional Film Production: Human editors have creative insights they bring into the editing process. They naturally have an idea about pacing, transition, and emotional subtlety that may be beyond the grasp of AI.

DISCUSSIONS

Pros of Human Editing:

Handcrafted VFX Work: Traditional creation of visual effects involves manual creation and compositing of effects by skilled artists; this is indeed a very laborious process but at the same time gives tremendous creative control and customization options.

Ethical and Creative Issues of AI:

The contribution of AI creates questions regarding authenticity in creative output and ownership rights and devaluation of human artists in creating any work .

Difference between Traditional and AI Film Festivals

Focus and Themes

Traditional Film Festivals: These festivals highlight a wide-ranging breadth of genres and storytelling approaches that hail the human creative spirit and artistic expression. They present films that represent visions for humanity, social





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causes, or important messages. A number of themes, ranging from dramatic and comic to documentary and experimental film.

AI Film Festivals: These festivals showcase stories that are heavily dependent on AI tools in their production or narrate how AI will influence the future world. They feature creative Two films that explore the potential of AI in vision creation, narrative development, and performance generation. Running parallel to the technical research, this also opens discussions on the ethical use of AI in filmmaking-the future of creativity and precisely what the role of technology is as opposed to art.

Submission and Selection Process:

Traditional Film Festivals: These are highly selective festivals in which films are selected based on are chosen based on their artistic merits, storytelling, and production values. Selection committees are usually composed of professionals in the industry.

Virtual AI Film Festivals: These highlight the aspects of innovation, and only those films which showcase new ways of using the AI technologies will be selected, and thus inspire filmmakers to try out new tools and techniques. This can also lure creators from genres leaning towards technology and digital art.

Audience Engagement and Experience

Classic Film Festivals: The classic film festivals provide for active audience involvement through discussion, question-and-answer sessions, and networking with the artists.

Artificial Intelligence Film Festivals - Interactive Experiences: Interaction within artificial intelligence film festivals might be applied to live demonstrations of AI technology, workshop activity, and deliberations on the future of AI in film.

Impact on Film Industry:

Traditional Film Festivals: Canonical Status of Film Festivals: Films get discovered, distribution contracts get signed, and prizes are awarded in conventional events such as Cannes, Sundance, and Tribeca. They powerfully influence culture as these festivals often set trends in film and influence civic discourses on important social issues.

AI Film Festivals: Growing Recognition Despite being relatively new, AI film festivals are fast gaining recognition as the place to show the future of filmmaking. [Distribution and Promotion of Traditional Films:](#)

Broadcast to the Masses: Films reach a wider audience through a network of theaters. They are also licensed to various TV networks for broadcast, reaching an even wider audience through the comfort of their living rooms.

Physical Distribution: Films are distributed through DVDs, Blu-rays, and other physical formats that people can purchase or rent. This appeals to collectors or those who do not have good access to the internet.

CONCLUSION

Distribution and Promotion in the Age of AI: Online Streaming Platforms: They distribute films through their online services and come up with recommendations based on a viewer's preferences and viewing history to extend discovery and guide viewers to films.

Social Media Marketing: AI chatbots and targeted advertisement in social media provide great interaction with the audience and sentiment analysis, thereby updating marketing strategies to make film advertising more dynamic.





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Predictive Analytics: AI can predict the success of a film using data available and informs decisions regarding the release date, marketing budget, and distribution channel.

Automation of Film Content Creation: AI technology can quickly analyze any movie to produce a trailer that captures the essence of the film, rating the overall experience swiftly. Investments by Nvidia and Google in film festivals using AI, such as the Runway AI Film Festival, are increasing their prestige in the tech world in several ways:

Leadership in AI Development: Participation in festivals about AI technology for movies places both Nvidia and Google ahead of others, having this technology. This alone signifies their commitment to innovation and creativity in the film industry and boosts their brand image and corporate identity as cutting-edge companies. The presence of AI across industries demonstrates its multifaceted and broad potential outside traditional boundaries, such as gaming and enterprise solutions.

Talent and Startup Attraction: Younger Creatives Engagement: In return for funding AI film festivals, companies can engage with newer filmmakers and technologists. This exposes them to discovering and attracting new talent that might be helpful in creating future AI and film innovations. Supporting Startups: By investing in these platforms, the tech giants foster relationships with startups and independent creators of AI-driven films. In return, this could provoke further partnerships and collaborations, even investment opportunities, in their strategic vision.

Brand Image Improvement: Encouraging a Relationship with Creativity and Art: In sponsoring AI film festivals, companies align their brands with creative expression and artistic interests. This could build a relationship with artists, filmmakers, and audiences at large that have a predilection for innovative storytelling.

Building Community Relations: Building Brand Image as Supportive Force in the Arts: Being part of these events helps the companies to draw public favor for themselves and build a positive brand image as supporters of the arts.

Shaping Industry Trends: Guiding Market Direction: The participation by these companies in the AI Film Festivals signals to the technology industry that this is a good market for AI in filmmaking and is lucrative. This could encourage more and more technology companies to invest in similar ventures.

AI film festivals are also attracting more investors: There is a dire need for strategic steps that show the promise of novelty, investors' opportunities, and the shifting face of filmmaking.

Key Strategies

Showcase Success Stories: Demonstrate how AI has actually added value to filmmaking by highlighting successful projects/case studies. Highlight those films that have gained critical acclaim or box office success with the help of AI technologies.

Workshops and Panel Discussions on Business Aspects of AI in Filmmaking: Organize workshops and panel discussions on the business aspects of AI in filmmaking to help potential investors.

Potential Risks: To the companies involved in product development, investment in AI film festivals has proved very beneficial, especially for those companies dealing in AI technologies. Such companies can utilize their participation in events of 'Demonstration of **Technology Capabilities**': AI film festivals provide a platform to the companies to show case their AI tools and technologies. Examples include how Runway's models could be featured by films shot using their software to illustrate their work and its use in practical applications. Revenue streams for the festival might include **Sponsorships and Partnerships**: AI film festivals draw sponsorships from technology companies like Nvidia and Google looking to showcase their AI tools and technologies in action, thus building awareness for the products of





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the sponsors Ticket Sales and Entry Fees: For most events, tickets are sold to attendees for screenings, panels, and workshops, and these may provide considerable income. Merchandising and Sales: Merchandise sold during the festival, such as branded items like t-shirts, posters, and other memorabilia, can be an added source of income. Workshops and Paid Educational Programs: Most AI film festivals organize workshops and master classes with professionals that can be arranged for a fee as another revenue line. Grants and Funding: Some festivals receive grants from arts and culture organizations or governments to further innovation in the arts. Investor Perspective: Investment Return: They are looking for projects that can realize commercial success, expansible growth, and innovative discontinuity to shake the market. Market Forecasts and Innovations: They interact with the prevailing market trends and signals

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2. .IBM WATSON.,Nvidea.,Google., Market research Biz., Market research news publication., Vision Research Reports., Art credits: Alistair, Phisigma, Gerd Altmann, Jean-Louis Servais, Jim Cooper, Suzy from [PixaBay], SCMP Graphics.,Sanscrata Navarasa prints.com, Arts peaksindia.com, massive.io flawless ai.com

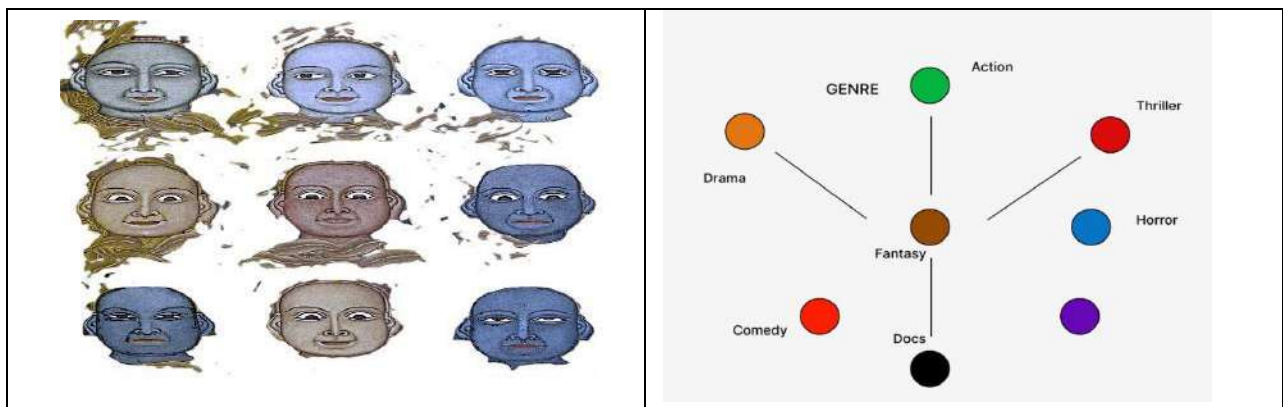


Fig.1. Logical Processing

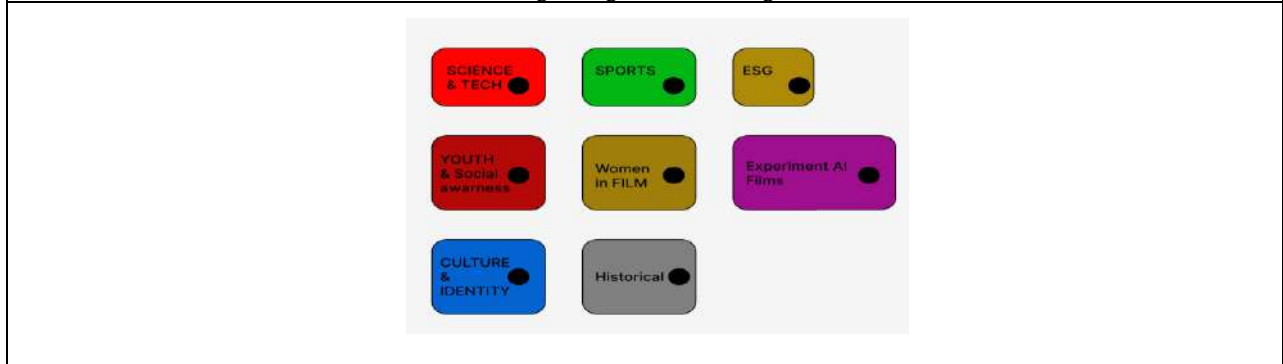


Fig.2.Topics





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Fig.3. Post-Production

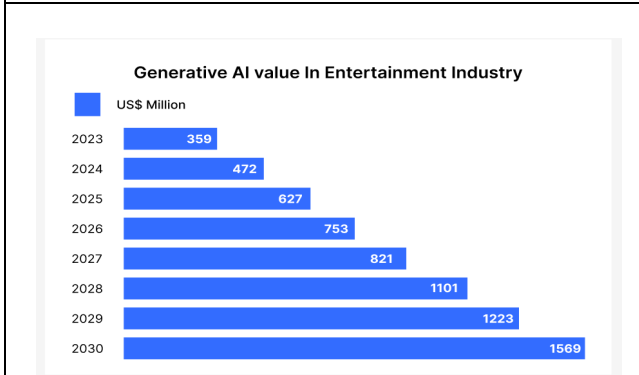


Fig.4

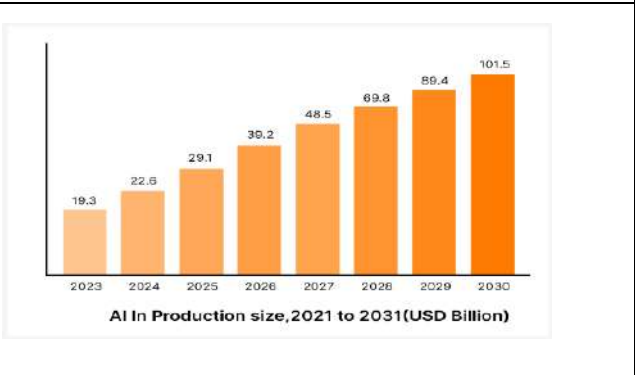


Fig.5.

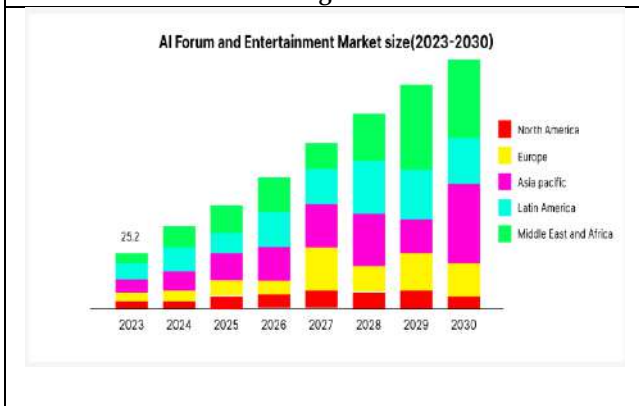


Fig.6

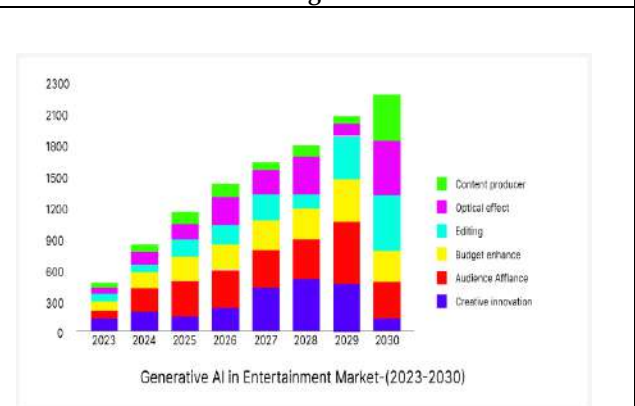


Fig.7





Natural Language Processing : Trends and Challenges

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ABSTRACT

Avant-garde of technological revolution, Natural Language Processing (NLP) is at the apex of computer science and Artificial Intelligence on one hand and linguistics on the other to facilitate a machine's ability to understand and analyze as well as generate speech in natural languages. The rising incidence of applying chatbots along with virtual assistants in the fields of customer care, health care, and personal assistance has led to the development of conversational AI being a priority. In accomplishing the language tasks, it has shifted the manner it can be done, enabling the study of the transfer of this model and reducing the complexity needed in the everyday, low-level task understanding. Language models have extended the sphere of application of NLP, and the range of languages used is constantly expanding, hence inclusive and variable language processing. Further, methodologies of transfer learning have enabled a quick increase in various aspects of natural language processing, such as data collection, analysis, attitude determination, and the dialogue component. Nevertheless, the NLP industry is still bearing many long-standing problems as Data Privacy, Bias, Context Understanding, Scalability of the model, Multi-modal Integration, Domain optimization and others. The call for real-time NLP applications of current techniques means that there is a need for an enhanced system that will accommodate and analyze large amounts of information within the shortest time possible with the objective of enabling the user to arrive at sustainable decisions, which are also comprehensible.

Keywords: NLP, Text Classification, Speech Recognition, Transformer Models, Language Models





INTRODUCTION

Natural Language Processing (NLP) is a branch of Artificial Intelligence (AI) that tries to address the gap between humans' ways of communicating and information processing machines. As a subject that uses methods from computer science, computational linguistics, and AI applied here, NLP allows the machine to comprehend language and find it meaningful and useful. This is mainly to enhance the aspect of human computer interface or interaction in which interaction between humans and computers or devices is enhanced through consumption of natural language processing. This is even more relevant in today's big data processing paradigm where new stories and speeches are created in real-time. Using the given information, an effective NLP system makes it easier to understand the information and analyze it with a view of improving the business processes and the decision-making process.

IMPORTANCE OF NLP

NLP is important for enriching technologies and enablement of natural ways through which people can engage a device. This is particularly relevant today as information flow is presented in the form of stories and speeches is increasing day by day due to the availability of big data. The described information can be preprocessed and analyzed by an effective NLP system to garner insights, enhance business operations, and optimize decision-making mechanisms.

Text analysis: on both the general comprehension of texts as well as the extraction of significant information from a text. This entails, for example, text mining involving such processes as; sentiment analysis, entity identification, data gathering and more.

Speech Recognition: transforms speech to text. The majority of modern gadgets and applications like Siri and Alexa make the usage of NLP while processing the voice commands.

Machine Translation: It convert text or spoken words form one language to another language. An example of this kind of application, which has widespread popularity, is Google Translate.

Natural Language Generation: It is text created from the data entered by the users, being a form of natural language content. It is used in tasks like chatbots and generating content automatically.

Information Retrieval: Assists to look for information from the large data by the online tools such as Google.

LITERATURE SURVEY

Comparison and Summary of The Literature Survey on Various Topics in Natural Language Processing (NLP) And Related Fields:

Knowledge Graphs

Hogan et al. (2021) in Artificial Intelligence Journal: This paper surveys the construction and utilization of knowledge graphs, emphasizing their role in enhancing NLP tasks through structured relational information. Applications include improved question answering systems, semantic search, and information retrieval [1].

Language Models

Devlin et al. (2019) in Transactions of the Association for Computational Linguistics (ACL): Introduced BERT, a bidirectional transformer model for language understanding that set new benchmarks across various NLP tasks by capturing context from both directions [2].

Vaswani et al. (2017) in Journal of Machine Learning Research (JMLR): Introduced the Transformer model, which relies on self-attention mechanisms, eliminating the need for recurrence and improving performance in tasks like machine translation and text summarization [3].



**Sakthi and Sumathy****Text Classification**

owsari et al. (2019) in Information Retrieval Journal: Reviewed traditional and modern text classification algorithms, highlighting the shift from traditional machine learning methods to deep learning approaches like CNNs, RNNs, and Transformers

Deep Learning Architectures

Young et al. (2018) in IEEE Transactions on Neural Networks and Learning Systems: Provided a comprehensive review of deep learning architectures (CNNs, RNNs, Transformers) applied to NLP, discussing their strengths, limitations, and applications [5]. Kim (2014) in IEEE Transactions on Pattern Analysis and Machine Intelligence: Demonstrated the effectiveness of CNNs for sentence classification, adapting them from image processing to text classification tasks [6].

Named Entity Recognition (NER)

Yadav and Bethard (2018) in Expert Systems with Applications: Reviewed deep learning models for NER, comparing approaches like CNNs, RNNs, and Transformers, and evaluating their performance on standard NER benchmarks [7].

Natural Language Generation (NLG)

Gatt and Krahmer (2018) in Artificial Intelligence Review: Provided a comprehensive review of NLG tasks such as text summarization, report generation, and dialogue systems, discussing evaluation metrics and the importance of NLG in creating coherent text [8].

Sequence-to-Sequence Models

Sutskever et al. (2014) in Journal of Artificial Intelligence Research (JAIR): Introduced the Seq2Seq model using LSTM networks, which revolutionized machine translation and sequence prediction tasks by effectively encoding and decoding sequences [9]. Cho et al. (2014) in Neural Computation: Developed the RNN Encoder-Decoder model for machine translation, significantly improving translation quality and efficiency [10].

Generative Models

Rezende et al. (2014) in Computational Linguistics: Explored variational auto encoders (VAEs) in NLP, enhancing the generative capabilities of models for tasks like text generation and language modelling [11].

Sentiment Analysis

Medhat et al. (2014) in ACM Computing Surveys: Reviewed various sentiment analysis approaches, including lexicon-based methods, machine learning techniques, and hybrid approaches, discussing their applications in social media monitoring and market research [12].

Key NLP Metrics Related To Trends And Challenges**Trends Metrics**

Model Size and Performance

GPT-3: 175 billion parameters; benchmarks like SuperGLUE score of 89.8 (as of its release).

BERT: 110 million parameters (base model); achieves 84.5 F1 score on the SQuAD 2.0 reading comprehension dataset.

Multimodal Models

CLIP (Contrastive Language-Image Pretraining): Can match images and texts with 76% accuracy in zero-shot image classification tasks.

DALL-E: Can generate images from text descriptions, achieving high fidelity and creativity.



**Sakthi and Sumathy****Low-resource Languages**

mBERT (Multilingual BERT): Supports 104 languages; performance varies with resource availability, but it improves over previous multilingual models

Conversational AI

Dialogflow (Google): Used in millions of conversations daily effectiveness varies by implementation and training.

Ethics and Fairness

Bias Benchmarks: Various benchmarks like the "Word Embedding Association Test" (WEAT) show biases in models (e.g., 60-70% of gender bias in word embeddings).

Challenges Metrics**Bias and Fairness**

Gender Bias: Models like word2vec show a 70% correlation with gender stereotypes in word associations.
Sentiment Analysis Bias: Models might misclassify sentiments by up to 15% depending on demographic attributes.

Data Privacy

Data Leakage: Incidents where sensitive data is inadvertently exposed can impact model trustworthiness; exact figures vary but incidents are reported regularly.

Interpretability

Explainability Techniques: Current explainability techniques (e.g., LIME, SHAP) have limitations in NLP, with effectiveness ranging between 60-80% in terms of interpretability.

Resource Intensity

Training Costs: Training large models like GPT-3 costs millions of dollars in computational resources.
Carbon Footprint: Training large NLP models can result in significant carbon emissions; estimates suggest that training GPT-3 can produce approximately 552,000 kg CO₂e.

Generalization

Domain Adaptation: Performance drop of 10-20% when models trained on one domain are applied to another without fine-tuning.

Trends: As of today, NLP fashions turn into more specialized in expertise context; shooting discords, context-changes, and dealing with multi-way conversations. This shift points at the need to increase the

relevance of context understanding in surrounding even higher correct and human-like models. Workers also are researching strategies to improve pass-area generalization, so as to increase NLP fashions' performance in other domains or subject areas. Also, as the use of applications that require translation like chatbots and virtual personal assistants increases in the near future, there may be pressure to enhance the speed of NLP models. These quantities have grow to be large and intricate, and the need to make them extra of a scale and exceptional has initiated cognate attempts to enhance scalability and performance.

Challenges: Nevertheless, some of the following difficulties are still present: As any other database system, the privateness and safety of the data are crucial troubles, significantly in relation to sensitive records, the protection of privateness remains the principle concern. Prejudice and inclusion are also active problems due to the fact that biases in NLP models should be avoided in order not to cause discrimination. Another undertaking is to work on the appropriate NLP fashions for low-sensible source languages that are nevertheless behind in terms of aid and



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accuracy. Last but not the least, the desire for better quality assessment is also implied, and enthusiasts strive to develop improved methods to compare the effectiveness of NLP models.

Data sources: Data collected from studies of language models including GPT-3, BERT (Base), mBERT, T5, and RoBERTa.

Analysis: This plot compares the model size of the models with their corresponding performance scores. The blue bars represent the image size, while the red lines indicate performance scores. GPT-3, with a larger model size, shows significantly higher performance scores. In contrast, BERT (Base), mBERT, T5, and RoBERTa, despite having smaller image sizes, maintain comparable performance scores, with T5 slightly outperforming the others in terms of performance time compared to its size.

Implications: The data shows that large models such as the GPT-3 can provide superior performance. However, smaller models such as BERT (Base), mBERT, and RoBERTa still achieve competitive performance, indicating that model efficiency and construction also play an important role in determining performance outcomes. This insight is valuable for models a choices based on trade-offs between computing resources and performance .

Data Source: Data amassed from performance critiques of NLP fashions with various sizes, measured in tens of millions of parameters.

Analysis: The plot demonstrates the version size and the actual-time processing capabilities or simply the request per second. The inverse courting also holds a lot of precision; the larger models are usually associated with diminished real-time processing capacity. As the version length grows, from round 2 hundred million parameters to more than 1 billion, the quality of generation improves significantly. When the quantity of parameters is 6 billion, the actual-time processing fee significantly decreases. This makes it imply that whereas larger models may also additionally provide for better accuracy or performance in sure duties, they will take greater computational resources, hence restricting their capability to procedure requests speedy.

Implications: This discovering is pivotal for actual-time applications that require fast decision- making and processing. Indeed, for scenarios where a large number of inputs need to be processed all at once, it could be beneficial to go for the small models even at the cost of accuracy. This alternate-offhas to be taken into consideration when deciding on models for the packages that need both performance and efficiency.

Data Source: The records for this evaluation become collected from overall performance opinions of numerous NLP models. These fashions have been tested with various sizes, measured in hundreds of thousands of parameters.

Analysis: Plot shows the mapping of model size with the Real Time processing capacity depicting the requests per second (RPS). As would be expected there is direct and inverse relationship, which is where as the size of the models increases the real time processing capability declines. While increasing the modelsize from a level of 200 million parameters to over a billion: Precisely, when working with approximately 6 billion parameters, the speed of real-time processing is hundreds of times less than what is exhibited above. This indicates that as much as larger models may claim to have better accuracy or performance in a given task, they are slower in processing requests due to the higher amount of recourses that they use.

Implications: However, this outcome is significant for any application type that requires fast computations in real time. Regarding the high-throughput computing applications, smaller models may work the best despite lesser accuracy, than larger ones. This trade-off becomes important when the models are being chosen for use in applications requiring both speed and resource optima.



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Data Source: The facts for this evaluation were obtained from the performance reviews of various NLP models, each tested with different sizes, in terms of hundreds of thousands of parameters.

Analysis: The plot shows the bias tiers of every extraordinary NLP models and the comparison of their ranges. The greatest degree of bias is formerly recommended by GPT-3, as indicated by means of the precise tallest bar inside the plot, at 70%. This implies that despite the fact that GPT-3 is highly developed, it is still biased to a certain extent. Per the bias degree discovered in CLIP, the mannequin has a 50% bias which means it's slightly biased – nonetheless, it is higher than some prior fashions and inferior to GPT-3. Moving to the next session with the lowest levels of bias we have word2vec with 45% bias degree. As you remember this level is not as high as GPT-3 or CLIP Nevertheless, word2vec demonstrates a rather significant degree of bias. Concerning the bias stage, BERT (Base) can be characterized as forty%, and that means that it is solely slightly much less prejudiced than word2vec however nevertheless a giant one. The bar with the shortest height illustrates T3 as possessing the lowest bias percentage at 25% indicating that several of the models had the lowest form of bias. This makes T3 a potentially higher preference for applications where fairness is pinnacle precedence.

Implications: Analyzing the tiers of bias is important in creating non-prejudiced AI systems hence constructing truthful structures. Higher bias stages result in discriminating outcomes; therefore, one should consider these measures when choosing or implementing models. Of course, to decrease the achievement of bias, builders need to implement offset mechanisms at some level of the training and quality-tuning stages in version development. Fostering solutions to bias can assist in the development of a fairer kind of AI packages.

CONCLUSION

The concept of NLP has come a long way and has even improved the manner that humans interface with computers. These enhancements of context, real-time, as well as cross-domain generalization make modern NLP models more realistic and powerful to implement the hitherto inconceivable applications. These are changes that are redefining specific sectors and they range from the customer service where chat bots are now being used to the healthcare system that is now employing virtual assistants to the creation of content and even language translation. But, the path does not end here. Nevertheless, numerous issues are still unresolved that can prevent the optimum performance of NLP. Data management, especially the question of privacy and protection, can be considered among these challenges because the use of big data implies work with large sets of sensitive data. Another important topic is bias mitigation as NLP models are increasingly integrated into more significant and consequential settings, and reinforcement of bias should be avoided. The problem of scalability is another one that becomes even more acute as models become larger and more complex and the useful techniques are needed to achieve the same level of performance in terms of scalability.

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Table 1. Literature Survey

Topic	Paper	Journal/Conference	Summary
Knowledge Graphs	Hogan et al. (2021)	Artificial Intelligence Journal	Surveys the construction and utilization of knowledge graphs, highlighting their role in enhancing NLP tasks such as question answering, semantic search, and information retrieval.
Language Models	Devlin et al. (2019)	Transactions of the Association for Computational Linguistics (ACL)	Introduced BERT, a bidirectional transformer model for language understanding that set new benchmarks across various NLP tasks by capturing context from both directions.
	Vaswani et al. (2017)	Journal of Machine Learning Research (JMLR)	Introduced the Transformer model, relying on self-attention mechanisms, eliminating the need for recurrence, and improving performance in tasks like machine translation and text summarization.
Text Classification	Kowsari et al. (2019)	Information Retrieval Journal	Reviewed traditional and modern text classification algorithms, highlighting the shift from traditional machine learning methods to deep learning approaches like CNNs, RNNs, and Transformers.
	Young et al.	IEEE Transactions on	Provided a comprehensive review of deep learning architectures





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Deep Learning Architectures	(2018)	Neural Networks and Learning Systems	(CNNs, RNNs, and Transformers) applied to NLP, discussing their strengths, limitations, and applications.
	Kim (2014)	IEEE Transactions on Pattern Analysis and Machine Intelligence	Demonstrated the effectiveness of CNNs for sentence classification, adapting them from image processing to text classification tasks.
Named Entity Recognition (NER)	Yadav and Bethard (2018)	Expert Systems with Applications	Reviewed deep learning models for NER, comparing approaches like CNNs, RNNs, and Transformers, and evaluating their performance on standard NER benchmarks.
Natural Language Generation (NLG)	Gatt and Krahmer (2018)	Artificial Intelligence Review	Provided a comprehensive review of NLG tasks such as text summarization, report generation, and dialogue systems, discussing evaluation metrics and the importance of NLG in creating coherent text.
Sequence-to-Sequence Models	Sutskever et al. (2014)	Journal of Artificial Intelligence Research (JAIR)	Introduced the Seq2Seq model using LSTM networks, revolutionizing machine translation and sequence prediction tasks by effectively encoding and decoding sequences.
	Cho et al. (2014)	Neural Computation	Developed the RNN Encoder-Decoder model for machine translation, significantly improving translation quality and efficiency.
Generative Models	Rezende et al. (2014)	Computational Linguistics	Explored variational autoencoders (VAEs) in NLP, enhancing the generative capabilities of models for tasks like text generation and language modeling.
Sentiment Analysis	Medhat et al. (2014)	ACM Computing Surveys	Reviewed various sentiment analysis approaches, including lexicon-based methods, machine learning techniques, and hybrid approaches, discussing their applications in social media monitoring and market research.





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Table 2. Trend and Challenges in NLP

Category	Trend/Challenge	Description
Trends	Pretrained Language Models	Rise of large-scale pretrained models such as GPT-3, BERT, T5, and their variants.
	Multimodal NLP	Integrating text with other data types like images, audio, and video.
	Few-Shot Learning	Techniques allowing models to perform tasks with little to no task-specific training data.
	Conversational Chatbots	Development of conversational agents. sophisticated
	Explainability Interpretability	Increasing focus on making NLP models more interpretable.
	Ethics and Bias Mitigation	Addressing ethical issues and biases in NLP models.
	Domain Adaptation and Customization	Tailoring models to specific industries or applications.
Challenges	Data Privacy and Security	Handling sensitive ensuring data privacy. information
	Bias and Fairness	NLP models inheriting biases from their training data.
	Low-Resource Languages	NLP models performing poorly on languages with limited annotated data.
	Context Understanding	Difficulty in understanding context, especially long-range dependencies.
	Evaluation Metrics	Existing metrics may not fully capture the quality and nuances of NLP tasks.
	Real-Time Processing	Processing and generating text in real-time.
	Scalability and Efficiency	Large models requiring significant computational resources.
	Cross-Domain Generalization	Models failing to generalize well across different domains.

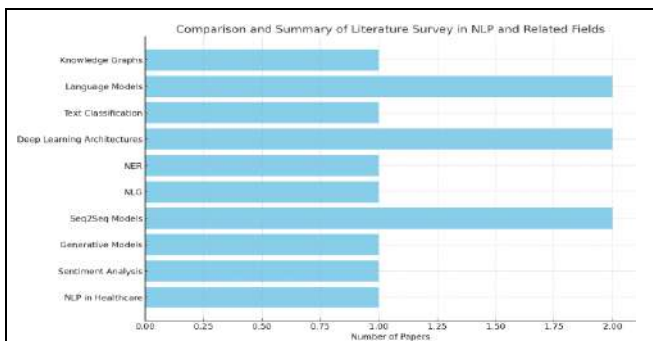


Fig. 1. Comparison Graph in NLP Rated fields

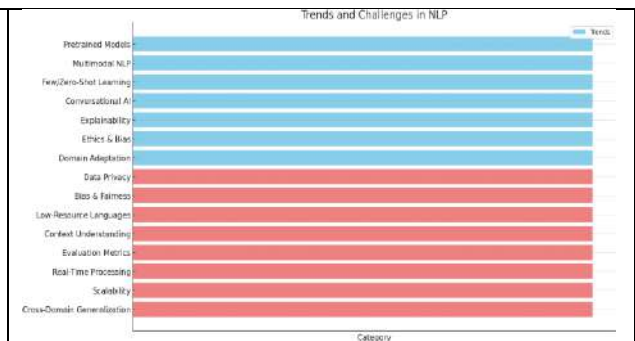


Fig. 2. Trend and Challenges in NLP





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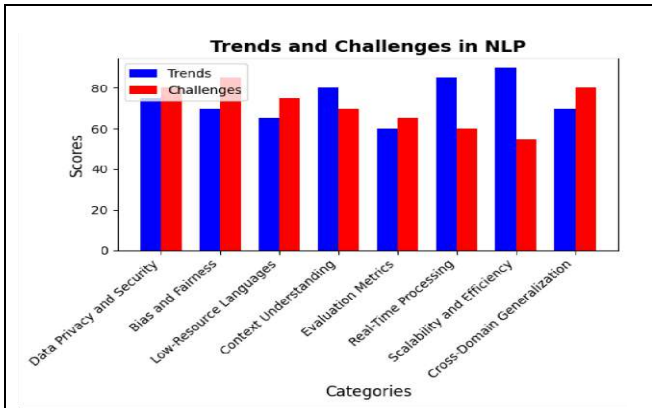


Fig. 3. Trends and Challenges in NLP

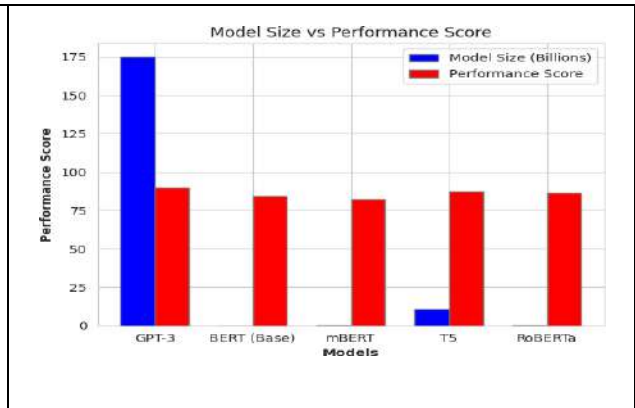


Fig. 4. Model size and performance scores

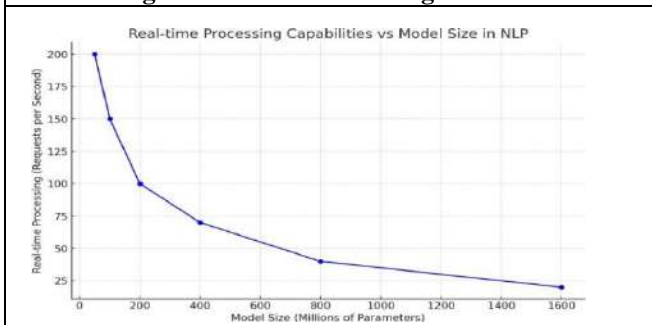


Fig 5. Real-time Processing Capabilities Vs Model Size in NLP

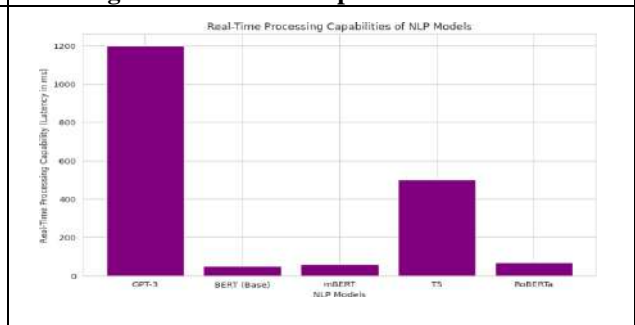


Fig 6. Real-time Processing Capabilities vs Model Size in NLP

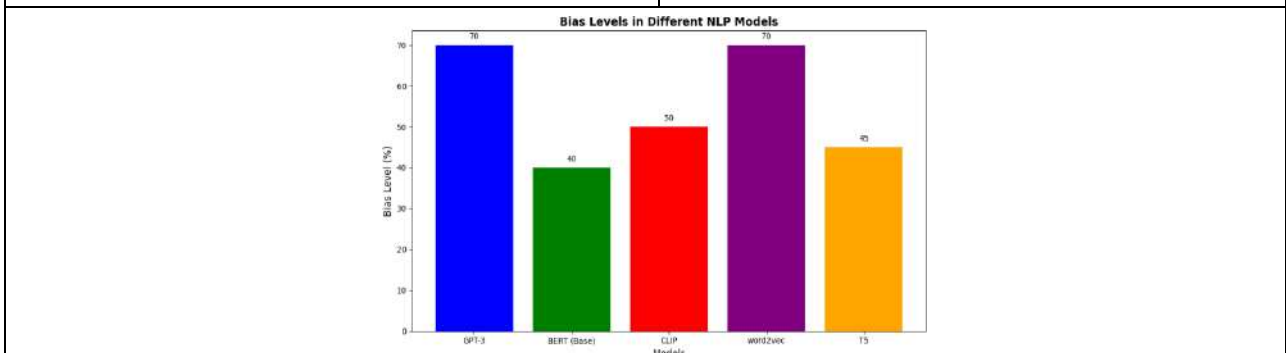


Fig.7. Bias Levels in Different NLP Models





On Hypersoft Topology

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ABSTRACT

Hypersoft sets are a generalization of soft sets that have gained importance and are being studied for possible uses in various mathematical fields. Musa and Asaad investigated numerous aspects and defined a number of fundamental concepts on hypersoft topological spaces. This work further develops the idea of hypersoft topology on hypersoft sets and looks at some of its characteristics, such as a hypersoft set's neighbourhood, closure, interior, limit point. We also introduce the notions of hypersoft basis, hypersoft subspace topology and hypersoft Hausdorff space. To help understand the recently defined concepts, examples are provided.

Keywords : Hypersoft set, hypersoft power set, hypersoft topology, hypersoft basis, subspace topology, closure, interior, limit point, and hypersoft Hausdorff space.

AMS Subject Classification: 54C50, 54F65.

INTRODUCTION

In 1999, Molodtsov [11] presented the idea of soft sets as a broad mathematical tool for handling various types of uncertainty. The proposal of soft topology utilising the soft sets provided by Cagman and Enginoglu [3] and the definition of a soft set using its soft subsets. Shabir and Naz [17] proposed the idea of soft topology defined on a classical set by utilising soft sets over it at the same era. Many studies have since been given on this idea, including [2,4-8,10,14-16,20,21].





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Smarandache[16] expanded the concept of soft sets into hypersoft sets by converting the argument function F into a multi-argument function. One recently developed method for solving realworld issues is the idea of hypersoft sets. The fundamental operations of union, intersection, complement, and difference of hypersoft sets were established by Mujahid Abbas et al. [1]. The foundations of hypersoft sets, including hypersoft subset, complement, not hypersoft set, and aggregation operations, were presented by Muhammad Saeed et al. [12]. Inthumathi et al.[9] presented the concepts of hypersoft semi-open sets, hypersoft semi-closed sets, hypersoft semiinterior and hypersoft semi-closure in hypersoft topological spaces (HTS). Recently Smarandache et al.[18] developed the concept of hypersoft sets in a game theory-based decision making model. Set theory concepts are central to modern topology. Musa and Asaad [13] investigated numerous aspects and defined a number of fundamental concepts on HTS. This work further develops the idea of hypersoft topology on hypersoft sets and looks at some of its characteristics, such as a hypersoft set's neighbourhood, closure, interior, limit point. We also introduce the notions of hypersoft basis, hypersoft subspace topology and hypersoft Hausdorff space.

PRELIMINARIES

The fundamental definitions and findings of hypersoft set theory that may be found in previous research are presented in this part.

Definition 2.1. [4]. A soft set F_A on the universe U is defined by the set of ordered pairs $F_A = \{(x, f_A(x)) : x \in E, f_A(x) \in P(U)\}$, where $f_A : E \rightarrow P(U)$ such that $f_A(x) = \Phi$ if $x \notin A$. Note that the set of all soft sets over U will be denoted by $S(U)$

Definition 2.2. [3]. Let $F_A \in S(U)$. A soft topology on F_A , denoted by τ , is a collection of soft subsets of F_A having the following properties:

- i. $F_\emptyset, F_A \in \tau$
- ii. $\{F_{A_i} \subseteq F_A \mid i \in I \subseteq N\} \subseteq \tau \Rightarrow \bigcup_{i \in I} F_{A_i} \in \tau$
- iii. $\{F_{A_i} \subseteq F_A : 1 \leq i \leq n, n \in N\} \subseteq \tau \Rightarrow \bigcap_{i=1}^n F_{A_i} \in \tau$

The pair (F_A, τ) is called a soft topological spaces.

Definition 2.3. [1]. Let U be a universe of discourse, $P(U)$ the power set U and E_1, E_2, \dots, E_n the pairwise disjoint sets of parameters. Let A_i be the nonempty subset of E_i for each $i = 1, 2, \dots, n$. A hypersoft set can be identified by the pair $(\phi, A_1 \times A_2 \times \dots \times A_n)$, where $\phi : A_1 \times A_2 \times \dots \times A_n \rightarrow P(U)$.

Throughout this work, we write the symbols E for $E_1 \times E_2 \times \dots \times E_n$, A for $A_1 \times A_2 \times \dots \times A_n$, \tilde{a} for an element of the set A and α for an element of the hypersoft set (ϕ, A) . We also suppose that none of the set A_i is empty. The set of all hypersoft sets over U will be denoted by $H[U]$

Example 2.4. [1]. Let $U = \{x_1, x_2, x_3, x_4\}$. Define the attributes sets by $E_1 = \{a_{11}, a_{12}\}$, $E_2 = \{a_{21}, a_{22}\}$, $E_3 = \{a_{31}, a_{32}\}$. Suppose that $A_1 = \{a_{11}, a_{12}\}$, $A_2 = \{a_{21}, a_{22}\}$, $A_3 = \{a_{31}\}$ are subsets of E_i for each $i = 1, 2, 3$ respectively. Let the hypersoft set (ϕ, A) be defined by

$$(\phi, A) = \{((a_{11}, a_{21}, a_{31}), \{x_1, x_2\}), ((a_{11}, a_{22}, a_{31}), \{x_2\}), ((a_{12}, a_{21}, a_{31}), \{x_3, x_4\}), ((a_{12}, a_{22}, a_{31}), \{x_1, x_4\})\}$$





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Definition 2.5. [1]. Let U be a universe of discourse and A a subset of E . Then (ϕ, A) is called

- i. a null hypersoft set if for each parameter $\tilde{\alpha} \in A$, $\phi(\tilde{\alpha})$ is an 0. We will denote it by Φ_A .
- ii. an absolute hypersoft set if for each parameter $\tilde{\alpha} \in A$, $\phi(\tilde{\alpha}) = U$. We will denote it by (ϕ, A) .

Definition 2.6. [1]. Let (ϕ, A) and (φ, B) be two hypersoft sets over U . Then (ϕ, A) is called a hypersoft subset of (φ, B) if $A \subseteq B$, and $\phi(\tilde{\alpha}) \subseteq \varphi(\tilde{\alpha})$ for all $\tilde{\alpha} \in A$.

We denote this by $(\phi, A) \subseteq (\varphi, B)$. Thus (ϕ, A) and (φ, B) are said to equal if $(\phi, A) \subseteq (\varphi, B)$ and $(\varphi, B) \subseteq (\phi, A)$.

Definition 2.7. [1]. Let (ϕ, A) and (φ, B) be two hypersoft sets over U . Then union of (ϕ, A) and (φ, B) is denoted by $(\psi, C) = (\phi, A) \cup (\varphi, B)$ with $C = C_1 \times C_2 \times \dots \times C_n$, where $C_i = A_i \cup B_i$ for $i = 1, 2, \dots, n$ and ψ is defined by

$$\psi(\tilde{\alpha}) = \begin{bmatrix} \phi(\tilde{\alpha}) & \text{if } \tilde{\alpha} \in A - B \\ \varphi(\tilde{\alpha}) & \text{if } \tilde{\alpha} \in B - A \\ \phi(\tilde{\alpha}) \cup \varphi(\tilde{\alpha}) & \text{if } \tilde{\alpha} \in A \cap B \\ 0 & \text{else} \end{bmatrix} \text{ Where } \tilde{\alpha} = (c_1, c_2, \dots, c_n) \in C.$$

Definition 2.8. [1]. Let (ϕ, A) and (φ, B) be two hypersoft sets over U . Then intersection of (ϕ, A) and (φ, B) is denoted by $(\psi, C) = (\phi, A) \cap (\varphi, B)$, where $C = C_1 \times C_2 \times \dots \times C_n$ is such that $C_i = A_i \cap B_i$ for $i = 1, 2, \dots, n$ and ψ is defined as $\psi(\tilde{\alpha}) = \phi(\tilde{\alpha}) \cap \varphi(\tilde{\alpha})$, where $\tilde{\alpha} = (c_1, c_2, \dots, c_n) \in C$. If C_i is an empty set for some i , then $(\phi, A) \cap (\varphi, B)$ is defined to be a null hypersoft set.

HYPERSOFT TOPOLOGY

The notion of hypersoft topology on a hypersoft set and its associated attributes are defined in this section.

Definition 3.1. Suppose (ϕ, A) be a hypersoft set. The hypersoft power set of (ϕ, A) is defined by $P[(\phi, A)] = \{(\phi, A)_i : (\phi, A)_i \subseteq (\phi, A), i \in I \subseteq N\}$ and its cardinality is defined by $|P[(\phi, A)]| = 2^{\sum_{\tilde{\alpha} \in A} |\phi(\tilde{\alpha})|}$, where $|\phi(\tilde{\alpha})|$ is the cardinality of $\phi(\tilde{\alpha})$

Example 3.2. Let $U = \{x_1, x_2, x_3\}$. Define the attributes sets by $E_1 = \{e_1, e_2, e_3\}$ $E_2 = \{e_4, e_5\}$ $E_3 = \{e_6, e_7\}$. Suppose that $A_1 = \{e_1, e_2\}$ $A_2 = \{e_4, e_5\}$ $A_3 = \{e_7\}$ are subsets of E_i for each $i = 1, 2, 3$ respectively. Let the hypersoft set (ϕ, A) be defined by $(\phi, A) = \{((e_1, e_4, e_7)\{x_1, x_2\}), ((e_2, e_5, e_7)\{x_2, x_3\})\}$. Consider all the hypersoft subsets of (ϕ, A) that are given by $(\phi, A)_1 = \{(e_1, e_4, e_7), \{x_1\}\}$, $(\phi, A)_2 = \{(e_1, e_4, e_7), \{x_2\}\}$, $(\phi, A)_3 = \{(e_1, e_4, e_7), \{x_1, x_2\}\}$, $(\phi, A)_4 = \{(e_2, e_5, e_7), \{x_2\}\}$, $(\phi, A)_5 = \{(e_2, e_5, e_7), \{x_3\}\}$, $(\phi, A)_6 = \{(e_2, e_5, e_7), \{x_2, x_3\}\}$, $(\phi, A)_7 = \{((e_1, e_4, e_7), \{x_1\}), ((e_2, e_5, e_7), \{x_2\})\}$, $(\phi, A)_8 = \{((e_1, e_4, e_7), \{x_1\}), ((e_2, e_5, e_7), \{x_3\})\}$, $(\phi, A)_9 = \{((e_1, e_4, e_7), \{x_1\}), ((e_2, e_5, e_7), \{x_2, x_3\})\}$, $(\phi, A)_{10} = \{((e_1, e_4, e_7), \{x_2\}), ((e_2, e_5, e_7), \{x_2\})\}$, $(\phi, A)_{11} = \{((e_1, e_4, e_7), \{x_2\}), ((e_2, e_5, e_7), \{x_3\})\}$, $(\phi, A)_{12} = \{((e_1, e_4, e_7), \{x_2\}), ((e_2, e_5, e_7), \{x_2, x_3\})\}$, $(\phi, A)_{13} = \{((e_1, e_4, e_7), \{x_1, x_2\}), ((e_2, e_5, e_7), \{x_2\})\}$, $(\phi, A)_{14} = \{((e_1, e_4, e_7), \{x_1, x_2\}), ((e_2, e_5, e_7), \{x_3\})\}$, $(\phi, A)_{15} = (\phi, A)$, $(\phi, A)_{16} = \Phi_A$, so $|P[(\phi, A)]| = 2^4 = 16$.





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Definition 3.3. Let $(\phi, A) \in H[U]$. A hypersoft topology on (ϕ, A) , denoted by τ , is a collection of hypersoft subsets of (ϕ, A) having the following properties.

- i. $\Phi_A, (\phi, A) \in \tau$
- ii. $\{(\phi, A)_j \subseteq (\phi, A) : j \in J \subseteq N\} \subseteq \tau \Rightarrow \bigcup_{j \in J} (\phi, A)_j \in \tau$
- iii. $\{(\phi, A)_j \subseteq (\phi, A) : 1 \leq j \leq n, n \in N\} \subseteq \tau \Rightarrow \bigcap_{j=1}^n (\phi, A)_j \in \tau$.

The pair $((\phi, A), \tau)$ is called a HTS.

Example 3.4. Let us consider the hypersoft subsets of (ϕ, A) that are given in Example 3.2 then

$$\begin{aligned} \tau_1 &= \{\Phi_A, (\phi, A)\} \\ \tau_2 &= P[(\phi, A)] \text{ and} \\ \tau_3 &= \{\Phi_A, (\phi, A), (\phi, A)_2, (\phi, A)_{11}, (\phi, A)_{13}\} \text{ are hypersoft topologies on } (\phi, A). \end{aligned}$$

Definition 3.5. Let $((\phi, A), \tau)$ be a HTS. Then every element of τ is called hypersoft open set. Clearly $\Phi_A, (\phi, A)$ are hypersoft open sets. A hypersoft set is closed hypersoft set if its complement is open hypersoft set

Definition 3.6. Let $((\phi, A), \tau_1)$ and $((\phi, A), \tau_2)$ be two HTSs. If $\tau_2 \supseteq \tau_1$, then τ_2 is finer than τ_1 or τ_1 is coarser than τ_2 . If $\tau_2 \supset \tau_1$, then τ_2 is strictly finer than τ_1 . If either $\tau_2 \supseteq \tau_1$ or $\tau_2 \subseteq \tau_1$, then τ_1 is comparable with τ_2 .

Example 3.7. Let us consider the hypersoft topologies on (ϕ, A) that are given in example 3.4. Then hypersoft topology τ_2 is finer than hypersoft topologies τ_1 and τ_3 , hypersoft topology τ_3 is finer than hypersoft topology τ_1 . So τ_1, τ_2 and τ_3 are comparable hypersoft topologies.

Definition 3.8. Let $((\phi, A), \tau)$ be a HTS and $\mathfrak{B} \subseteq \tau$. If every element of τ can be written as the union of elements of \mathfrak{B} , then \mathfrak{B} is called a hypersoft basis for the hypersoft topology τ . Each element of \mathfrak{B} is called a hypersoft basis element.

Example 3.9. Let us consider Examples 3.2 and 3.4. Then $\mathfrak{B} = \{\Phi_A, (\phi, A)_1, (\phi, A)_2, (\phi, A)_4, (\phi, A)_5\}$ is a hypersoft basis for the hypersoft topology τ_2 .

Theorem 3.10. Let $((\phi, A), \tau)$ and $((\phi, A), \tau')$ be two HTSs and $\mathfrak{B}, \mathfrak{B}'$ be hypersoft bases for τ and τ' respectively. If $\mathfrak{B}' \subseteq \mathfrak{B}$, then τ is finer than τ' .

Proof. Let $\mathfrak{B}' \subseteq \mathfrak{B}$. Then for each $(\phi, B) \in \tau'$ and $(\psi, C) \in \mathfrak{B}'$
 $(\phi, B) = \bigcup_{(\psi, C) \in \mathfrak{B}'} (\psi, C) = \bigcup_{(\psi, C) \in \mathfrak{B}} (\psi, C)$. Therefore $(\phi, B) \in \tau$, hence $\tau' \subseteq \tau$

Theorem 3.11. Let $((\phi, A), \tau)$ be a HTS and \mathfrak{B} be hypersoft basis for τ . Then τ is the collection of union of elements of \mathfrak{B} .

Proof: The proof is trivial.

Definition 3.12. Let $((\phi, A), \tau)$ be a HTS and $(\phi, B) \subseteq (\phi, A)$. Then the collection $\tau_{(\phi, B)} = \{(\phi, A)_i \cap (\phi, B) : (\phi, A)_i \in \tau, i \in I \subseteq N\}$ is called a hypersoft subspace topology on (ϕ, B) . Hence, $((\phi, B), \tau_{(\phi, B)})$ is called a hypersoft topological subspace of $((\phi, A), \tau)$.

Theorem 3.13. Let $((\phi, A), \tau)$ be a HTS and $(\phi, B) \subseteq (\phi, A)$. Then a hypersoft subspace topology on (ϕ, B) is a hypersoft topology.

Proof: Indeed, it contains Φ_A and (ϕ, B) because $\Phi_A \cap (\phi, B) = \Phi_A$ and $(\phi, A) \cap (\phi, B) = (\phi, B)$, where $\Phi_A, (\phi, A) \in \tau$. Since $\tau = \{(\phi, A)_i : (\phi, A)_i \subseteq (\phi, A), i \in I\}$ is closed under finite intersections and arbitrary unions. $\bigcap_{i=1}^n ((\phi, A)_i \cap (\phi, B)) = (\bigcap_{i=1}^n (\phi, A)_i) \cap (\phi, B)$

$$\bigcup_{i \in I} ((\phi, A)_i \cap (\phi, B)) = (\bigcup_{i \in I} (\phi, A)_i) \cap (\phi, B)$$





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Example 3.14. Let us consider the hypersoft topology τ_3 on (ϕ, A) given in example 3.4. If $(\varphi, B) = (\phi, A)_9$, then hypersoft subspace topology $\tau_{(\varphi, B)} = \{\phi_A, (\phi, A)_9, (\phi, A)_5, (\phi, A)_7\}$, and so $((\varphi, B), \tau_{(\varphi, B)})$ is a hypersoft topological subspace of $((\phi, A), \tau_3)$.

Theorem 3.15. Let $((\phi, A), \tau)$ be a HTS, $((\varphi, B), \tau_{(\varphi, B)})$ be a hypersoft topological subspace. If (ψ, C) is hypersoft open in $\tau_{(\varphi, B)}$, then there exists at least one element (χ, D) of τ such that $(\psi, C) \subseteq (\chi, D)$.

Proof: It is clearly seen from Definition 3.12.

Theorem 3.16. Let $((\phi, A), \tau)$ be a HTS. If \mathfrak{B} is a hypersoft basis for τ , then the collection $\mathfrak{B}_{(\varphi, B)} = \{(\phi, A)_i \cap (\varphi, B) : (\phi, A)_i \in \mathfrak{B}, i \in I \subseteq N\}$ is a hypersoft basis for the hypersoft subspace topology on (φ, B) .

proof : Take as given each $(\psi, C) \in \tau_{(\varphi, B)}$. From the definition of hypersoft subspace, $(\psi, C) = (\chi, D) \cap (\varphi, B)$, where $(\chi, D) \in \tau$. Because $(\chi, D) \in \tau$, $(\chi, D) = \cup_{(\phi, A)_i \in \mathfrak{B}} (\phi, A)_i$. Therefore $(\psi, C) = (\cup_{(\phi, A)_i \in \mathfrak{B}} (\phi, A)_i) \cap (\varphi, B) = \cup_{(\phi, A)_i \in \mathfrak{B}} ((\phi, A)_i \cap (\varphi, B))$. Hence $\mathfrak{B}_{(\varphi, B)}$ is a hypersoft basis for hypersoft subspace topology $\tau_{(\varphi, B)}$ on (φ, B) .

Theorem 3.17. Let $((\phi, A), \tau)$ be a HTS. Then the following conditions hold

- i. The empty set ϕ_A and (ϕ, A) are hypersoft closed sets.
- ii. Arbitrary intersections of the hypersoft closed sets are hypersoft closed.
- iii. Finite unions of the hypersoft closed sets are hypersoft closed.

Proof:

- i. By the definition of hypersoft closed set, $(\phi, A)^c = \phi_A$ and $\phi_A^c = (\phi, A)$ are hypersoft open. Then (ϕ, A) and ϕ_A are hypersoft closed.
- ii. If $\{(\phi, A)_i : (\phi, A)_i^c \in \tau, i \in I \subseteq N\}$ is a given collection of hypersoft closed sets, then $(\cap_{i \in I} (\phi, A)_i)^c = \cup_{i \in I} (\phi, A)_i^c$ is hypersoft open. Therefore $\cap_{i \in I} (\phi, A)_i$ is a hypersoft closed set.
- iii. If $(\phi, A)_i$ is hypersoft closed for $i = 1, 2, 3, \dots, n$. Then $(\cup_{i=1}^n (\phi, A)_i)^c = \cap_{i=1}^n (\phi, A)_i^c$ is hypersoft open. Hence $\cup_{i=1}^n (\phi, A)_i$ is a hypersoft closed set.

Definition 3.18. Let $((\phi, A), \tau)$ be a HTS and $(\varphi, B) \subseteq (\phi, A)$. Then the hypersoft interior of (φ, B) , denoted $(\varphi, B)^\circ$, is defined as the union of all hypersoft open subsets of (φ, B) . $(\varphi, B)^\circ = \cup \{(\varphi, B)_i : (\varphi, B)_i \in \tau, (\varphi, B)_i \subseteq (\varphi, B), i \in I \subseteq N\}$.

Note that $(\varphi, B)^\circ$ is the biggest hypersoft open set that is contained by (φ, B) .

Example 3.19. Let us consider the hypersoft topology τ_3 given in example 3.4.

Let $(\varphi, B) = (\phi, A)_{12} = \{((e_1, e_4, e_7), \{x_2\}), ((e_2, e_5, e_7), \{x_2, x_3\})\}$. Then the hypersoft interior of (φ, B) , $(\varphi, B)^\circ = \phi_A \cup (\phi, A)_2 \cup (\phi, A)_{11} = (\phi, A)_{11}$.





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Theorem 3.20. Let $((\phi, A), \tau)$ be a HTS and $(\phi, B) \subseteq (\phi, A)$. (ϕ, B) is a hypersoft open set if and only if $(\phi, B) = (\phi, B)^\circ$.

Proof : If (ϕ, B) is an hypersoft open set, then the biggest hypersoft open set that is contained by (ϕ, B) is equal to (ϕ, B) . Therefore $(\phi, B) = (\phi, B)^\circ$. Conversely, it is known that $(\phi, B)^\circ$ is a hypersoft open set, and if $(\phi, B) = (\phi, B)^\circ$, then (ϕ, B) is hypersoft open set.

Theorem 3.21. Let $((\phi, A), \tau)$ be a HTS and $(\phi, B), (\psi, C) \subseteq (\phi, A)$. Then

- i. $((\phi, B)^\circ)^\circ = (\phi, B)^\circ$
- ii. $((\phi, B) \subseteq (\psi, C) \Rightarrow (\phi, B)^\circ \subseteq (\psi, C)^\circ$
- iii. $(\phi, B)^\circ \cap (\psi, C)^\circ = ((\phi, B) \cap (\psi, C))^\circ$
- iv. $(\phi, B)^\circ \cup (\psi, C)^\circ \subseteq ((\phi, B) \cup (\psi, C))^\circ$

Proof:

- i. Let $(\phi, B)^\circ = (\chi, D)$. Then $(\chi, D) \in \tau$ iff $(\chi, D) = (\chi, D)^\circ$. Therefore $((\phi, B)^\circ)^\circ = (\phi, B)^\circ$.
- ii. Let $(\phi, B) \subseteq (\psi, C)$. From the definition of a hypersoft interior, $(\phi, B)^\circ \subseteq (\phi, B)$ and $(\psi, C)^\circ \subseteq (\psi, C)$. $(\psi, C)^\circ$ is the biggest hypersoft open set that is contained by (ψ, C) . Hence, $(\phi, B) \subseteq (\psi, C) \Rightarrow (\phi, B)^\circ \subseteq (\psi, C)^\circ$
- iii. By the definition of a hypersoft interior, $(\phi, B)^\circ \subseteq (\phi, B)$ and $(\psi, C)^\circ \subseteq (\psi, C)$. Then $(\phi, B)^\circ \cap (\psi, C)^\circ \subseteq (\phi, B) \cap (\psi, C)$. $((\phi, B) \cap (\psi, C))^\circ$ is the biggest hypersoft open set that is contained by $((\phi, B) \cap (\psi, C))$. Hence, $(\phi, B)^\circ \cap (\psi, C)^\circ \subseteq ((\phi, B) \cap (\psi, C))^\circ$. Conversely, $(\phi, B) \cap (\psi, C) \subseteq (\phi, B)$ and $(\phi, B) \cap (\psi, C) \subseteq (\psi, C)$ Then, $((\phi, B) \cap (\psi, C))^\circ \subseteq (\phi, B)^\circ$ and $((\phi, B) \cap (\psi, C))^\circ \subseteq (\psi, C)^\circ$. Therefore, $((\phi, B) \cap (\psi, C))^\circ \subseteq (\phi, B)^\circ \cap (\psi, C)^\circ$.
- iv. Let $(\phi, B)^\circ \subseteq (\phi, B)$ and $(\psi, C)^\circ \subseteq (\psi, C)$. Then $(\phi, B)^\circ \cup (\psi, C)^\circ \subseteq (\phi, B) \cup (\psi, C)$. $((\phi, B) \cup (\psi, C))^\circ$ is the biggest hypersoft open set that is contained by $(\phi, B) \cup (\psi, C)$. Hence, $(\phi, B)^\circ \cup (\psi, C)^\circ \subseteq ((\phi, B) \cup (\psi, C))^\circ$.

Definition 3.22. Let $((\phi, A), \tau)$ be a HTS and $(\phi, B) \subseteq (\phi, A)$. Then the hypersoft closure of (ϕ, B) denoted by $\overline{(\phi, B)}$, is defined as the intersection of all hypersoft closed supersets of (ϕ, B) . $\overline{(\phi, B)} = \bigcap \{(\phi, A)_i : (\phi, A)_i^c \in \tau, (\phi, B) \subseteq (\phi, A)_i, i \in I \subseteq N\}$. Note that $\overline{(\phi, B)}$ is the smallest hypersoft closed set that containing (ϕ, B) .

Example 3.23. Let us consider the hypersoft topology τ_3 given in example 3.4. If $(\phi, B) = (\phi, A)_9 = \{((e_1, e_4, e_7), \{x_1\}), ((e_2, e_5, e_7), \{x_2, x_3\})\}$ then $(\phi, A)_2^c = (\phi, A)_9 = \{((e_1, e_4, e_7), \{x_1\}), ((e_2, e_5, e_7), \{x_2, x_3\})\}$ and $\Phi_A^c = (\phi, A) = \{((e_1, e_4, e_7), \{x_1, x_2\}), ((e_2, e_5, e_7), \{x_2, x_3\})\}$ are hypersoft closed supersets of (ϕ, B) . Hence $\overline{(\phi, B)} = (\phi, A)_9 \cap (\phi, A) = (\phi, A)_9$

Theorem 3.24. Let $((\phi, A), \tau)$ be a HTS and $(\phi, B) \subseteq (\phi, A)$. (ϕ, B) is a hypersoft closed set iff $(\phi, B) = \overline{(\phi, B)}$.

Proof: The proof is trivial.

Theorem 3.25. Let $((\phi, A), \tau)$ be a HTS and $(\phi, B) \subseteq (\phi, A)$. Then $(\phi, B)^\circ \subseteq (\phi, B) \subseteq \overline{(\phi, B)}$.

Proof: The proof is trivial.





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Theorem 3.26. Let $((\phi, A), \tau)$ be a HTS and $(\phi, B), (\psi, C) \subseteq (\phi, A)$. Then

- i. $\overline{(\phi, B)} = \overline{(\phi, B)}$
- ii. $(\phi, B)^c = ((\phi, B)^c)^\circ$
- iii. $(\psi, C) \subseteq (\phi, B) \Rightarrow \overline{(\psi, C)} \subseteq \overline{(\phi, B)}$
- iv. $\overline{(\phi, B) \cap (\psi, C)} \subseteq \overline{(\phi, B)} \cap \overline{(\psi, C)}$
- v. $\overline{(\phi, B) \cup (\psi, C)} = \overline{(\phi, B)} \cup \overline{(\psi, C)}$

Proof:

- i. Let $\overline{(\phi, B)} = (\chi, D)$. Then (χ, D) is a hypersoft closed set. Therefore (χ, D) and $\overline{(\chi, D)}$ are equal. Hence $\overline{(\phi, B)} = \overline{(\phi, B)}$.
- ii. If we consider the definitions of a hypersoft closure and a hypersoft interior, we obtain
$$\overline{(\phi, B)}^c = \left(\bigcap_{\substack{(\phi, A)_i \supseteq (\phi, B) \\ (\phi, A)_i^c \in \tau}} (\phi, A)_i \right)^c = \bigcup (\phi, A)_i^c = ((\phi, B)^c)^\circ$$
- iii. Let $(\psi, C) \subseteq (\phi, B)$. By the definition of a hypersoft closure, $(\phi, B) \subseteq \overline{(\phi, B)}$ and $(\psi, C) \subseteq \overline{(\psi, C)}$. $\overline{(\psi, C)}$ is the smallest hypersoft closed set that containing (ψ, C) . Then $\overline{(\psi, C)} \subseteq \overline{(\phi, B)}$.
- iv. Let $\overline{(\phi, B)}$ and $\overline{(\psi, C)}$ are hypersoft closed sets. So $\overline{(\phi, B)} \cap \overline{(\psi, C)}$ is a hypersoft closed set. Since $(\phi, B) \cap (\psi, C) \subseteq \overline{(\phi, B)} \cap \overline{(\psi, C)}$ and $\overline{(\phi, B)} \cap \overline{(\psi, C)}$ is the smallest hypersoft closed set that containing $(\phi, B) \cap (\psi, C)$, $\overline{(\phi, B) \cap (\psi, C)} \subseteq \overline{(\phi, B)} \cap \overline{(\psi, C)}$.
- v. Let $(\phi, B) \subseteq \overline{(\phi, B)}$ and $(\psi, C) \subseteq \overline{(\psi, C)}$. Then $(\phi, B) \cup (\psi, C) \subseteq \overline{(\phi, B)} \cup \overline{(\psi, C)}$. Since $\overline{(\phi, B) \cup (\psi, C)}$ is the smallest hypersoft closed set that containing $(\phi, B) \cup (\psi, C)$, $\overline{(\phi, B) \cup (\psi, C)} \subseteq \overline{(\phi, B)} \cup \overline{(\psi, C)}$. Conversely, $(\psi, C) \subseteq \overline{(\psi, C)} \subseteq \overline{(\phi, B) \cup (\psi, C)}$ and $(\phi, B) \subseteq \overline{(\phi, B)} \subseteq \overline{(\phi, B) \cup (\psi, C)}$. Therefore, $\overline{(\phi, B) \cup (\psi, C)} \subseteq \overline{(\phi, B)} \cup \overline{(\psi, C)}$. Hence, $\overline{(\phi, B) \cup (\psi, C)} = \overline{(\phi, B)} \cup \overline{(\psi, C)}$

Definition 3.27. Let $((\phi, A), \tau)$ be a HTS and $\alpha \in (\phi, A)$. If there is a hypersoft open set $(\phi, B) \in \tau$ such that $\alpha \in (\phi, B)$, then (ϕ, B) is called a hypersoft neighborhood of α . The set of all hypersoft neighborhood of α denoted by $HN(\alpha)$, is called the family of hypersoft neighborhoods of α , $HN(\alpha) = \{(\phi, B) : (\phi, B) \in \tau, \alpha \in (\phi, B)\}$

Example 3.28. Let us consider the HTS $((\phi, A), \tau_3)$ in Example 3.4 and $\alpha = ((e_1, e_4, e_7), \{x_1, x_2\}) \in (\phi, A)$. Then $HN(\alpha) = \{(\phi, A), (\phi, A)_{13}\}$

Definition 3.29. Let $((\phi, A), \tau)$ be a HTS, $(\phi, B) \subseteq (\phi, A)$ and $\alpha \in (\phi, A)$. If every neighborhood of α intersects (ϕ, B) in some points other than α itself, then α is called a hypersoft limit point of (ϕ, B) . The set of all limit points of (ϕ, B) is denoted by $(\phi, B)'$. In other words, if $((\phi, A), \tau)$ is a HTS, $(\phi, B), (\psi, C) \subseteq (\phi, A)$ and $\alpha \in (\phi, A)$, then $\alpha \in (\phi, B)' \Leftrightarrow (\psi, C) \cap ((\phi, B) \setminus \{\alpha\}) \neq \phi_A$ for all $(\psi, C) \in HN(\alpha)$.

Example 3.30. Let us consider the Example 3.28. If $(\phi, B) = (\phi, A)_{13}$ and $\alpha = ((e_1, e_4, e_7), \{x_1, x_2\}) \in (\phi, A)$ then $\alpha \in (\phi, B)'$. Since $(\phi, A) \cap ((\phi, B) \setminus \{\alpha\}) \neq \phi_A$ and $(\phi, A)_{13} \cap ((\phi, B) \setminus \{\alpha\}) \neq \phi_A$





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Theorem 3.31. Let $((\phi, A), \tau)$ be a HTS and $(\phi, B) \subseteq (\phi, A)$. Then $(\phi, B) \cup (\phi, B)' = \overline{(\phi, B)}$.

Proof: If $\alpha \in (\phi, B) \cup (\phi, B)'$ then $\alpha \in (\phi, B)$ or $\alpha \in (\phi, B)'$. In this case, if $\alpha \in (\phi, B)$ then $\alpha \in \overline{(\phi, B)}$. If $\alpha \in (\phi, B)'$, then $(\psi, C) \cap ((\phi, B) \setminus \{\alpha\}) \neq \Phi_A$ for all $(\psi, C) \in HN(\alpha)$ and so $(\psi, C) \cap (\phi, B) \neq \Phi_A$ for all $(\psi, C) \in HN(\alpha)$. Hence $\alpha \in \overline{(\phi, B)}$. Conversely, if $\alpha \in \overline{(\phi, B)}$, then $\alpha \in (\phi, B)$ or $\alpha \notin (\phi, B)$. In this case, if $\alpha \in (\phi, B)$ it is trivial that $\alpha \in (\phi, B) \cup (\phi, B)'$. If $\alpha \notin (\phi, B)$ then $(\psi, C) \cap ((\phi, B) \setminus \{\alpha\}) \neq \Phi_A$ for all $(\psi, C) \in HN(\alpha)$. Therefore $\alpha \in (\phi, B)'$ so $\alpha \in (\phi, B) \cup (\phi, B)'$. Hence $(\phi, B) \cup (\phi, B)' = \overline{(\phi, B)}$.

Theorem 3.32. Let $((\phi, A), \tau)$ be a HTS, and $(\phi, B) \subseteq (\phi, A)$. Then (ϕ, B) is hypersoft closed if and only if $(\phi, B)' \subseteq (\phi, B)$.

Proof: $\overline{(\phi, B)} = (\phi, B) \Leftrightarrow (\phi, B) \cup (\phi, B)' = (\phi, B) \Leftrightarrow (\phi, B)' \subseteq (\phi, B)$.

Theorem 3.33. Let $((\phi, A), \tau)$ be a HTS and $(\phi, B), (\psi, C) \subseteq (\phi, A)$. Then

- i. $(\phi, B)' \subseteq \overline{(\phi, B)}$
- ii. $(\phi, B) \subseteq (\psi, C) \Rightarrow (\phi, B)' \subseteq (\psi, C)'$
- iii. $((\phi, B) \cap (\psi, C))' \subseteq (\phi, B)' \cap (\psi, C)'$
- iv. $((\phi, B) \cup (\psi, C))' = (\phi, B)' \cup (\psi, C)'$

Proof:

- i. It is clearly seen from theorem 3.31.
- ii. Let $\alpha \in (\phi, B)'$. Then $(\chi, D) \cap ((\phi, B) \setminus \{\alpha\}) \neq \Phi_A$ for all $(\chi, D) \in HN(\alpha)$. Since $(\phi, B) \subseteq (\psi, C)$, $(\chi, D) \cap ((\psi, C) \setminus \{\alpha\}) \neq \Phi_A$ for all $(\chi, D) \in HN(\alpha)$. In other words $\alpha \in (\psi, C)'$. Hence $(\phi, B)' \subseteq (\psi, C)'$.
- iii. $(\phi, B) \cap (\psi, C) \subseteq (\phi, B)$ and $(\phi, B) \cap (\psi, C) \subseteq (\psi, C)$. Then $((\phi, B) \cap (\psi, C))' \subseteq (\phi, B)'$ and $((\phi, B) \cap (\psi, C))' \subseteq (\psi, C)'$. Therefore, $((\phi, B) \cap (\psi, C))' \subseteq (\phi, B)' \cap (\psi, C)'$
- iv. $(\phi, B) \subseteq (\phi, B) \cup (\psi, C)$ and $(\psi, C) \subseteq (\phi, B) \cup (\psi, C)$. Then $(\phi, B)' \subseteq ((\phi, B) \cup (\psi, C))'$ and $(\psi, C)' \subseteq ((\phi, B) \cup (\psi, C))'$. Therefore $(\phi, B)' \cup (\psi, C)' \subseteq ((\phi, B) \cup (\psi, C))'$. Conversely, for all $(\chi, D) \in HN(\alpha)$, $\alpha \in ((\phi, B) \cup (\psi, C))' \Leftrightarrow (\chi, D) \cap [((\phi, B) \cup (\psi, C)) \setminus \{\alpha\}] \neq \Phi_A \Leftrightarrow (\chi, D) \cap [(\phi, B) \setminus \{\alpha\} \cup (\psi, C) \setminus \{\alpha\}] \neq \Phi_A \Leftrightarrow [(\chi, D) \cap ((\phi, B) \setminus \{\alpha\})] \neq \Phi_A$ or $[(\chi, D) \cap ((\psi, C) \setminus \{\alpha\})] \neq \Phi_A \Leftrightarrow \alpha \in (\phi, B)'$ or $\alpha \in (\psi, C)'$ $\Leftrightarrow \alpha \in (\phi, B)' \cup (\psi, C)'$. Hence $((\phi, B) \cup (\psi, C))' \subseteq (\phi, B)' \cup (\psi, C)'$. Thus $((\phi, B) \cup (\psi, C))' = (\phi, B)' \cup (\psi, C)'$.





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Definition 3.34. Let $((\phi, A), \tau)$ be a HTS. If $\forall \alpha_1, \alpha_2 \in (\phi, A), \alpha_1 \neq \alpha_2$, there exists $(\varphi, B)_1 \in HN\{\alpha_1\}$ and $(\varphi, B)_2 \in HN\{\alpha_2\}$ such that $(\varphi, B)_1 \cap (\varphi, B)_2 = \phi_A$, then $((\phi, A), \tau)$ is called hypersoft Hausdorff space.

Example 3.35. Let $U = \{x_1, x_2, x_3\}$ and $E_1 = \{e_1, e_2, e_3\}$ $E_2 = \{e_4, e_5\}$ $E_3 = \{e_6, e_7\}$. Consider the hypersoft set $(\phi, E) = \{((e_1, e_4, e_7), \{x_1, x_2\}), ((e_2, e_5, e_7), \{x_2, x_3\}), ((e_3, e_4, e_6), \{x_1, x_3\})\}$.

If $(\phi, E)_1 = \{((e_1, e_4, e_7), \{x_1, x_2\}), ((e_3, e_4, e_6), \{x_1\})\}$, $(\phi, E)_2 = \{((e_2, e_5, e_7), \{x_2, x_3\}), ((e_3, e_4, e_6), \{x_3\})\}$. Then $\tau = \{\phi_A, (\phi, E), (\phi, E)_1, (\phi, E)_2\}$ is a hypersoft topology on (ϕ, E) . Hence $((\phi, E), \tau)$ is a hypersoft Hausdorff space.

Theorem 3.36. Every finite point hypersoft set in a hypersoft Hausdorff space is a hypersoft closed set.

Proof : Let $((\phi, A), \tau)$ be a hypersoft Hausdorff space. It suffices to show that every one point set $\{\alpha_1\}$ is hypersoft closed. If $\alpha_2 \neq \alpha_1$ is a point of (ϕ, A) , then α_1 and α_2 have disjoint hypersoft neighborhoods $(\varphi, B)_1$ and $(\varphi, B)_2$ respectively. Since $(\varphi, B)_1$ does not intersect $\{\alpha_2\}$, point α_1 cannot belong to the hypersoft closure of the set $\{\alpha_2\}$. As a result, the hypersoft closure of the set $\{\alpha_1\}$ is $\{\alpha_1\}$ itself, so it is hypersoft closed.

Definition 3.37. Let $((\phi, A), \tau)$ be a HTS and $(\varphi, B) \subseteq (\phi, A)$. Then the hypersoft boundary of (φ, B) denoted $(\varphi, B)^b$, is defined by $(\varphi, B)^b = \overline{(\varphi, B)} \cap \overline{(\varphi, B)^c}$

Example 3.38. Let us consider Example 3.23. For (φ, B) , $\overline{(\varphi, B)} = (\phi, A)_2^c$ and $\overline{(\varphi, B)^c} = (\phi, A)$. Then $(\varphi, B)^b = \overline{(\varphi, B)} \cap \overline{(\varphi, B)^c} = (\phi, A)_2^c$

Theorem 3.39. Let $((\phi, A), \tau)$ be a HTS, and $(\varphi, B), (\psi, C) \subseteq (\phi, A)$. Then

- i. $(\varphi, B)^b \subseteq \overline{(\varphi, B)}$
- ii. $(\varphi, B)^b = \overline{((\varphi, B)^c)^b}$
- iii. $(\varphi, B)^b = \overline{(\varphi, B)} \setminus (\varphi, B)^\circ$

Proof :

- i. From the definition of a hypersoft boundary, the proof is trivial.
- ii. Take as given $\alpha \in (\varphi, B)^b$
 $\Leftrightarrow (\psi, C) \cap (\varphi, B) \neq \phi_A$ and $(\psi, C) \cap (\varphi, B)^c = \phi_A$ for all $(\psi, C) \in HN\{\alpha\}$.
 $\Leftrightarrow (\psi, C) \cap (\varphi, B)^c \neq \phi_A$ and $(\psi, C) \cap ((\varphi, B)^c)^c \neq \phi_A$ for all $(\psi, C) \in HN\{\alpha\}$.
 Hence $(\varphi, B)^b = \overline{((\varphi, B)^c)^b}$.
- iii. Consider the definitions of a hypersoft closure and a hypersoft interior.

$$\begin{aligned} \overline{(\varphi, B)} \setminus (\varphi, B)^\circ &= \overline{(\varphi, B)} \cap ((\varphi, B)^\circ)^c = \overline{(\varphi, B)} \cap \left(\bigcup_{\substack{(\varphi, B)_i \subseteq (\varphi, B) \\ (\varphi, B)_i \in \tau}} (\varphi, B)_i \right)^c \\ &= \overline{(\varphi, B)} \cap (\cap (\varphi, B)_i^c) = \overline{(\varphi, B)} \cap \overline{(\varphi, B)^c} = (\varphi, B)^b. \end{aligned}$$





CONCLUSION

One important branch of mathematics is topology. We introduced the idea of hypersoft topology on a hypersoft set and discussed its associated aspects in this work. The theoretical underpinnings of HTSs were then presented. This study might serve as a foundation for hypersoft set theoretic operations-based mathematical structures and notions. Many topological space features can be extended to HTS in the future.

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Isolation and Identification of Symbiotic Bacteria (*Xenorhabdus*) from Entomopathogenic Nematode

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ABSTRACT

Entomopathogenic nematodes represent a group of soil inhabiting nematodes that parasitize a wide range of insects. These nematodes belong to two families: Steinernematidae and Heterorhabditidae. Until now, more than 70 species have been described in Steinernematidae and there are about 20 species in Heterorhabditidae. The nematodes have a mutualistic partnership with Enterobacteriaceae bacteria and together they act as a potent insecticidal complex that kills a wide range of insect species. Many nematodes are associated with insects and their host interactions range from beneficial to detrimental. The pathogenic effect is in fact conferred by their interaction with facultative anaerobic enteric bacteria. The bacteria are vectored from one insect host to another by the only free-living nematode stage, the third-stage infective juvenile which lives in soil. Once inside the insect, the nematodes release the bacteria into the insect's hemolymph, which kill the insect host by massive septicemia. In the present investigation is to isolate *Xenorhabdus*(symbiotic bacteria) from EPN . It also focuses on the insect-baiting technique, a widely used approach for the isolation of EPN from soil samples, and the modified white trap technique which is popularly used for the recovery of these nematodes from infected insects. The third segment of the cadaver was given a cut to extract hemolymph. The hemolymph was streaked on sterile plates of Nutrient Bromothymol Blue Triphenyltetrazolium chloride agar NBTA. The Plates was incubated at 28°





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C in dark for 4 days. After 4 days of incubation, bacterial colonies were observed. The characteristics of the colonies was dark blue, convex and swarm colonies. There will be a phase shift from blue to orange and finally the colonies will be observed as yellowish orange colour.

Keywords: *Xenorhabdus*, EPN, Triphenyl tetrazolium chloride, Bromothymolblue

INTRODUCTION

Xenorhabdus spp. (members of the family Enterobacteriaceae) are symbiotically associated with Entomopathogenic nematodes in the families Steinernematidae and Heterorhabditidae, the nematodes act as vectors transporting their bacterial symbionts in to the hemocoel of the insect host. *Xenorhabdus* spp. contribute to the symbiotic relationship by providing nutritional requirements for their nematode partners. Economic importance of entomopathogenic nematodes (EPN) belonging to the genera Steinernema is increasing because of their potential use in biological control of numerous pests (Gaugler and Kaya 1990). The non feeding infective juveniles carry the symbiotic bacteria, *Xenorhabdus* in their gut. The nematode search for an ambush a suitable insect host, enter through natural opening and also through cuticle and release their symbiont bacteria into the hemolymph. Proliferation of the bacterium leads to death of the insect host within 24-48 hours followed by nematode development and reproduction (Kaya et al., 1993) The Genus *Xenorhabdus* -Steinernema life cycle insect larvae are infected and killed, while both mutualists produce bioactive compounds, a single strain of *Xenorhabdus* may produce a variety of antibacterial and antifungal compounds, some of which are also active against insects, nematodes, Protozoa and cancer cells. *Xenorhabdus* spp., entomopathogenic bacteria symbiotically associated with the nematode of the family steinernematidae are shown to produce different lipases when they are grown on suitable nutrient agar. *Xenorhabdus* spp. occur spontaneously in two variants, phase I and phase II. Phase I variants absorb dyes on agar plates produce several antibiotics, secrete a variety of proteins. The main objectives of our study were to isolate and identify EPNs and their symbiotic Bacteria of *Xenorhabdus*. The main objective of the present research was to isolate and identify EPNs and their Symbiotic Bacteria of *Xenorhabdus*.

MATERIALS AND METHODS

Soil Sample Collection

10 Samples were collected from two locations at Tirunelveli and Kanyakumari district. Soil Samples with plant debris were taken from a diverse of habitats, for example cashew, golden showers, coconut, mango, ixora, Date palm, Nerium Plant from Tirunelveli district (The Indian Agriculture College) and coconut, mango, Banana, Tamarind, Jack fruit from Seynamvilai village of kanyakumari district.

Mass multiplication of EPN

The EPNs were isolated from the soil samples using the *C. cephalonica* Baiting technique as described by Bedding and Akhurst. White trap were used to isolate the emerging infective juvenile EPNs from the *C. cephalonica* cadavers. The infective juveniles of EPN were collected in 100 ml of clean sterile distilled water. The infective juveniles of EPN were surface sterilized by adding 1 ml 0.25 % (w/v) to the suspension and washed with sterile water 2 to 3 times in the Laminar air flow chamber with a sterile micro pipette, most of the supernatant was removed without disturbing the infective juveniles settled at the bottom of the tube. At the final step the surface sterilized infective juveniles which were collected in a beaker with sterile distilled water. The juvenile nematodes kept at 13-15° C in distilled water prior to molecular identification.

Isolation of *Xenorhabdus* from the Nematodes:

Xenorhabdus bacteria were isolated from the hemolymph of rice moth larval cadavers (*Corcyra cephalonica*) infected with EPN's. To propagate EPN's (500µl) was placed on to a sterile petridish containing 5 larvae of rice moth (C



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cephalonica). The petridish was then sealed with parafilm and incubated in the dark at room temperature. The insect larvae was observed daily for 2-3 days. The resulting insect cadavers were then washed with 95-100% ethanol and placed on another sterile petridish. The third segment from the mouth parts of the *C.cephalonica* larvae were opened using fine sterile forceps to obtain the hemolymph containing *Xenorhabdus*. A drop of hemolymph was streaked on sterile plates of nutrient bromothymol blue triphenyl tetrazolium chloride agar (NBTA) which were then stored in the dark at room temperature. After 4 days of incubation, preliminary identification of these bacteria was performed by observing the colony morphology. The colonies of species of the genus *Xenorhabdus* are dark blue, convex, umbonated and swarm. This yellowish orange colour due to the phase shift from blue to orange.

NBTA Media Composition

Nutrient Bromothymol blue triphenyl tetrazolium chloride agar:

Nutrient agar	8.0 g
Bromomethyl blue	25 mg
2,3,5-trimethyl	40 mg
tertazolium chloride	
distilled water	1000 ml

Molecular Identification of *Xenorhabdus* Species

Sequence analysis of twelve isolates was done to confirm species identity, which initially has been done based solely on morphological parameters. Comparison of oligonucleotide fragments of 16SrRNA sequences, which included the 5.8 S gene and the flanking ITS1 and ITS2 regions, with reference sequences from public databases, showed that they were very similar. (Santhana Bharathi S and Reetha, 2022)

RESULTS AND DISCUSSION

Based on the colony morphology on the NBTA *Xenorhabdus* were isolated from the EPNs (Entomopathogenic Nematode) and were preliminarily characterized based on a dark blue, or dark red colony colour with a convex or umbonated surface and swarming colony on NBTA after three to four days at room temperature (25° C). EPNs are able to infect a broad host range of insects, but in terms of symbiosis the relationship between the host nematode and its symbiont i.e. bacterium is very close. Taxonomic studies by using morphological, biochemical and molecular analysis of conserved genes of genera i.e., *Xenorhabdus* in steinernema and *photorhabdus* in heterorhabditis were conducted by several investigators (Euzeby and Boemare, 2000, Boemare and Akhurst, 2000, 2001; Akhurst and Boemare, 2001). EPNs were obtained from infected *C.cephalonica* larvae. The first phenotypic evidence in the identification of these bacteria was the cadavers colouration. Those *C.cephalonica* infected by steinernema become brownish colour. *Xenorhabdus* are unique in the bacterial world and beneficial due to their ability to form a mutualistic symbiosis in one host and mount an aggressive pathogenic against a totally different phylum. The selected isolate TCX 1 were molecular level characterized by 16S rRNA sequencing and identified as *Xenorhabdusnematophila* the sequence data were submitted to the NCBI Gen Bank, and the allocated accession number is OR633290. A Phylogenetic tree was also constructed using the 16S rDNA gene sequence data at Figure 7.

>OR633290 *Xenorhabdusnematophila* - TCX

CONCLUSION

Xenorhabdus is an important component in Integrated pest management strategies. In the present study reported the TCX *Xenorhabdusnematophila* exhibit a monoxenic association between each isolate and its nematode by amplifying and sequencing bacterial 16S rRNA sequence from crushed adult and juvenile nematode and from bacterial cultures isolated from infected hosts.





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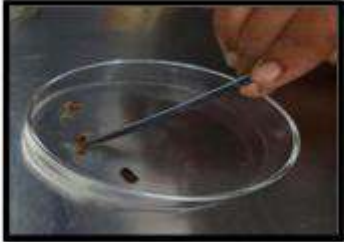

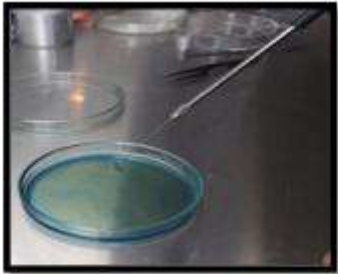
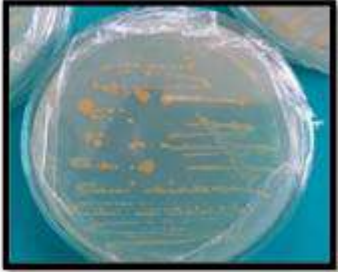
Table1: Identified species: *Xenorhabdusnematophila*

Selected Isolates	Locations (Tirunelveli)	Source	Selected Isolates	Locations (kanyakumari)
T1-TCX	TIAC-Cashew	Soil	T8-KCX	Coconut
T2-TGX	TIAC-Golden Shower	Soil	T9-KMX	Mango
T3-TCOX	TIAC-Coconut	Soil	T10-KBX	Banana
T4-TMX	TIAC-Mango	Soil	T11- KTX	Tamarind
T5-TIX	TIAC-Ixora	Soil	T12- KJX	Jack Fruit
T6 -TDX	TIAC-Date Palm	Soil		
7-TNX	TIAC-Nerium Plant	Soil		





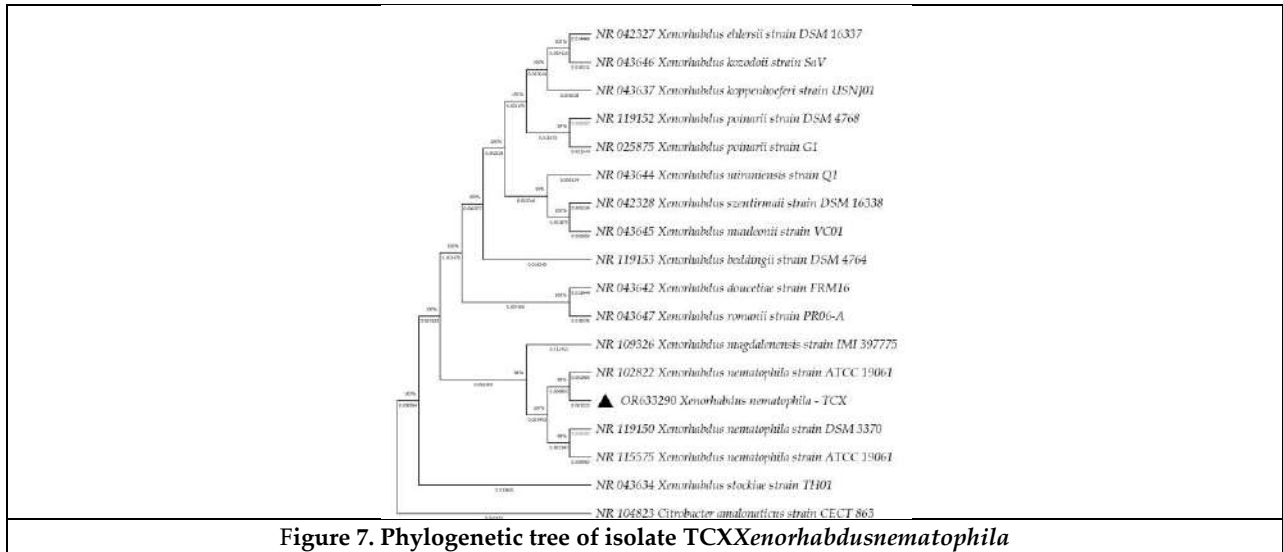
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<p>FIGURE :1 Rice moth larva infected with EPN</p>	<p>FIGURE:2 Surface Sterlized with 70% Ethanol</p>
	
<p>FIGURE:3 Cutting of cadavar at 3rd segment</p>	<p>FIGURE:4Taking Hemolymph from Corcyra larva</p>
	
<p>FIGURE :5 Hemolymph streaked on NBTA Media</p>	<p>FIGURE:6 <i>Xenorhabdus</i> CULTURE</p>





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Review of Global and Ongoing Sustainable Environment Policies for Implementation of BGI in India

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ABSTRACT

Globally, there is a growing recognition of the importance of blue-green infrastructure for sustainable development. Several policies for sustainability can be implemented for environmental and infrastructure planning, however relating to the nature-based sustainable model i.e., blue-green infrastructure, the development becomes unorganized. This paper intends to focus on the review of global policies for implementing blue-green infrastructure and the ongoing environment and sustainable policies used for implementing BGI in India. However, there is a gap, as no such policy in India is directly related to the integrated blue-green infrastructure in the Inclusive planning process. Moreover, the fragmented nature of policymaking in India also contributes to the gaps between policy and implementation. The above-mentioned gap between policy and implementation of blue-green infrastructure in India requires a comprehensive framework of ongoing policies in a global context which can be further overlapped with the existing sustainable and environmental policies of India in identifying the gap since the implementation of sustainable policies for blue-green infrastructure which is directly responsible towards the environment is crucial for ensuring long-term environmental, social, and economic sustainability. The methods used for the research are purely qualitative, the paper describes the detailed global and Indian policies and best practices related to BGI.

Keywords: Infrastructure planning, Blue-Green Infrastructure, Sustainability, Environment policy, Inclusive Planning



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INTRODUCTION

Multifunctional infrastructures are appealing to society because they can integrate urban ecology with reliable and efficient spaces. [1]. “The term 'blue-green' or 'green/blue' infrastructure developed at the turn of the previous decade as a rising awareness of the need for a more integrated systems-approach to the management of Green and Blue Infrastructure. [2].” It (BGI) refers to an integrated system of created and natural elements that work together to manage water resources, enhance biodiversity, reduce flooding risk, and provide other environmental and socioeconomic benefits. BGI is seen as an essential investment and an advancement over traditional infrastructure. [3]. In context with the BGI, the 11th Sustainable Development Goals established by the United Nations General Assembly in 2015 as Sustainable Cities and Communities, the main aim of this goal is “to make cities inclusive, resilient, safe and sustainable [4].” SDG 11 promotes inclusive and sustainable urbanization. It includes investments in public transit, better urban planning and resource management, as well as measures for climate adaptation and disaster resilience. SDGs are now widely recognized as a framework to shape sustainability initiatives within governments and NGOs [5]. Similar to this, activities aimed towards particular SDGs in line with a long-term vision are increasingly integrating sustainability reporting into projects or organization plans. A growing number of nations are establishing policies and programs to encourage the use of BGI as a crucial instrument for climate change adaptation and sustainable development. Cities like Melbourne, Rotterdam, and Portland have become models in this regard. [6].

Background

The EPA defined two spatial scales for green infrastructure in its definition. At the city or county scale, green infrastructure refers to “the patchwork of natural areas that provide habitat, flood protection, cleaner air and cleaner water”, whereas at the neighborhood or site scale, green infrastructure refers to “storm water management systems that mimic nature soak up and store water [7, 8].” “Natural infrastructure and blue infrastructure are the two most recently coined terms.” [9, 10] “Natural infrastructure was first used to emphasise the importance of wetlands in freshwater system management.” [11] The “Blue” recognizes the importance of the physicality of water and works on the principles of utilizing rainwater, allowing its infiltration and managing the storm water that drains off the land into waterways and corridors, while the “Green” connects urban hydrological functions with vegetation systems in urban landscape design. The resulting BGI has overall socio-economic benefits that are greater than the sum of the individual components. Following the debates at the Rio Earth Summit in 1992, Swedish legislation was changed to emphasise sustainability, notably the necessity of green space in and around cities. According to the new legislation, urban planning should promote a healthy living environment, biodiversity, and the effective use of energy and other resources. [12]

METHODOLOGY

The methodology had three major steps for identification of potential BGI Literature review firstly review of ongoing global BGI policies and Projects with extracting the major parameters taken into consideration. Second is the review of existing policies indirectly related to BGI in India. And the third and final step is the comparative analysis of both policy initiative related to both Indian and Global context in context of overlapping of policies, parameters, sectoral plans and gaps.

Blue-green Infrastructure & Sustainable Development

A sustainable city is one that maintains a balance of economic, social, and ecological components. Integrating all effective BGI initiatives, as well as derived services, may unlock the true potential of BGI strategies in improving our towns and cities. [13]. Urbanisation not only influences landscape characteristics but also affects the process of natural systems such as the hydrological cycle, greenhouse gas emissions, biodiversity levels, and metal and nutrient biochemical cycles. [14]. Blue-green infrastructure serves both people and animals. Its presence can improve air and water quality, carbon storage, as well as flood and temperature management, noise reduction, resource



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efficiency, biodiversity, and amenity value. These features, in turn, increase resistance to the effects of climate change, including increased temperatures and flooding. BGI has primarily received excellent feedback in nations such as the Netherlands; yet, widespread adoption appears to be challenging due to a lack of awareness

Importance of blue-green infrastructure in sustainable development

The covid-19 pandemic has impacted global and domestic funding capacity for projects related to the UN's sustainable development goals (SDG's). blue-green infrastructure has the potential to fulfill multiple targets outlined in the SDGs, such as those related to Clean water & sanitation (SDG 6), Life on land (SDG 15), climate action (SDG 13), Sustainable cities & communities (social inclusion) (SDG 11) although it can also accelerate progress on green employment prospects (SDG 8), positions in agriculture, manufacturing, R&D, administrative, and service activities aimed at substantially preserving or restoring environmental quality) Followed by these SDGs' various co-factors are related to the sustainability criteria of these SDGs and are important key connections between blue-green infrastructure and sustainable development that are as follows:

- Climate Change Mitigation and Adaptation: Blue-green infrastructure aids in climate change mitigation by sequestering carbon dioxide, cutting energy usage, and minimizing urban heat island effects. It also increases urban resilience by mitigating the effects of extreme weather events through storm water management, flood control, and soil erosion prevention.
- Water Management and Quality: Blue-green infrastructure incorporates natural water management measures such as rain gardens, artificial wetlands, and green roofs to collect and filter storm water runoff.
- Social and health benefits: Blue-green infrastructure improves urban people' quality of life by establishing green places for recreation, increasing air quality, and minimising noise pollution.
- Economic Opportunities: By producing green jobs, attracting investments, and increasing property values, blue-green infrastructure may produce economic advantages.

Challenges in implementing blue-green Infrastructure

Uncertainties surrounding hydrological performance and service delivery, as well as a lack of faith in communities and decision-makers to accept, support, and take holding of such infrastructure, are impeding the widespread adoption of Blue-Green Infrastructure (BGI). When compared to solely hydrological factors, social-institutional hurdles often provide the greatest challenge to the implementation of sustainable water management systems and have a stronger effect on the selected solution. [15] General approaches such as enhancing education and promoting awareness are critical to public understanding of BGI, often lack specifics and may require additional refining to overcome the various challenges in practice. [16] A study was conducted in new castle, an interview analysis was done using qualitative research software, with asking two major nodes i.e., Barriers to BGI' and 'Overcoming barriers' According to the study's findings, more than half of those polled stated that a lack of understanding, education, and awareness about BGI is a major obstacle to obtaining financing (including paying for continuing maintenance) from local governments and the general public, with three primary barriers being physical science/engineering uncertainty, a lack of suitable space, and future land use and climate.[16].

Review of global policies of BGI

International cities are shifting away from depending on just centralized grey infrastructure and towards decentralized facilities that employ BGI to locally retain, store, and reuse surface water, hence increasing their resilience to possible environmental difficulties.

Best Practices in blue-green infrastructure implementation**Case of: Blue-Green Cities Research Project, UK**

By integrating water management and green infrastructure, a Blue-Green City aims to replicate a naturally directed water cycle while also contributing to the city's amenity. This is accomplished by integrating and conserving the urban landscape's hydrological and biological assets while also offering robust and adaptive flood mitigation methods. The Blue-Green Cities Research Consortium sought to create innovative ways for controlling urban flood risk as part of a larger, integrated urban planning effort aiming at environmental enhancement and urban



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rejuvenation, with the numerous advantages of Blue-Green Cities systematically examined and understood [17]. The project's stakeholders were to be its primary focus, and the drainage systems were to be updated. Risks would be mitigated by studying gaps in the urban drain networks, developing adaptable strategies with the communities, establishing a flood footprint to estimate financial costs, identifying obstacles to flood prevention, and putting in place blue-green infrastructure.

Case of: Grey to Green Initiative, Portland, US

Portland has one of the oldest and most effective BGI programs in the country, and over the past 20 years, it has made significant investments in BGI to reduce the burden on the piped infrastructure system, enhance the quality of the water, and control the danger of flooding. The five-year 'Grey to Green' effort aided in the execution of the Portland Watershed Management Plan (2005), with overarching aims of safeguarding natural resources, restoring important ecosystems, and adopting storm water solutions that integrate urban regions with the natural environment [18]. The initiative highlighted aspects such as street and yard tree planting, green streets and eco-roofs. [19].

Case of : Rotterdam, Netherlands

Rotterdam is a pioneer city in the transition to transformational climate governance. [20].and has a long history of combining urban water management, spatial planning, and climate change adaptation to increase the city's resilience to, for example, sea level rise and increasing occurrence of pluvial flood events, while improving the quality of life of urban residents. [21] Potential benefits of project were divided into three criteria: health, energy and carbon detachment; and community live ability with individual statistics to calculate best management practices, and a validity scale that is used to illustrate the benefit's certainty degree. [22]

Case of: Active, Beautiful, Clean Waters Programme, Singapore

The Active, Beautiful, Clean (ABC) Waters Programme was launched in 2006 by Singapore's Public Utilities Department under the Ministry of Environment and Water Resources to realize the full potential of a progressively implemented drainage network of 17 reservoirs and 8,000 km of drains, canals, and rivers. Because catchment regions cover two-thirds of Singapore, holistic and sustainable storm water management was launched using onsite detention and retention systems, even as the need for more community engagement was recognized. [23]. The ABC Waters program's main goal was to turn streams and bodies of water into magnificent urban assets by integrating these drainage systems with the built environment and bringing people closer to water.

Case of: Sponge city, Wuhan, China

Due to current flooding and pollution challenges, the Wuhan government prioritized tackling the issue of water logging and complemented this with water pollution management and rainfall collecting and reuse through the sponge city project. Total 455 sponge projects were planned in the city's two demonstration regions, i.e., Qingshang and Six in Districts, which comprise 38.5 square kilometers [24].

Policy Frameworks and initiatives**Environment and sustainable policies in India****Overview**

For acknowledging the importance of the environment, implementing sustainable policies in India is a need for a better future. A better understanding of the relationship between the environment and sustainable policy in India involves the term "environmental sustainability." Some aspects of environment sustainability for policy initiatives involve investment in water conservation, support for sustainable transportation, renewable energy, environmental conservation, and innovation in urban planning. In response to the UN Framework Convention on Climate Change and the UN's 'Green Economy Initiative,' India implemented the National Action Plan on Climate Change (NAPCC) in 2008. The initiative listed out the macroeconomic, sustainability, and poverty reduction implications of green investment in sectors like renewable energy and sustainable agriculture, and also guided catalysing increased investment in these areas.



**Ananya Tripathi and Subhrajit Banerjee****Existing policies relevant to blue-green infrastructure**

Green infrastructure was first referenced in an early debate of India's environmental policy in the Fourth Five Year Plan (1964-69), and it covers a wide range of challenges, including regulating air and water pollution and protecting forests, mangroves, and other natural resources. Renamed the Ministry of Environment, Forests, and Climate Change in 2014, it remains the focal point for environmental and climate policy planning, monitoring, and implementation, while the Ministry of Water Resources and Ganga Development oversees India's national water resources (the country's blue infrastructure). [25] Some of the existing policies that are relevant to the blue-green infrastructure are elaborated below:

- National Water Policy (2012): This policy focuses on the sustainable development and management of water resources, including the promotion of water conservation, rainwater harvesting, and efficient water use.
- National Mission for Sustainable Agriculture (NMSA): NMSA aims to promote sustainable agricultural practices, including water management, watershed development, and soil conservation.[26]
- National Urban Greening Guidelines: These guidelines provide recommendations for integrating green spaces into urban planning and development, promoting urban forests, parks, and green infrastructure.
- National River Conservation Plan (NRCP): NRCP is aimed at addressing water pollution and promoting the conservation and rejuvenation of rivers, which can contribute to BGI principles.
- National Mission for Clean Ganga (Namami Gange): is a prominent initiative aimed at restoring and protecting the Ganga River. The mission includes several projects, including sewage treatment, riverfront development, and riverbank afforestation. These initiatives not only boost the Ganga River's quality of water but also enhances overall blue-green infrastructure along the river.
- Sustainable habitat, water, agricultural, and forestry missions are multisectoral, overlapping, and cross-departmental in nature. [27] From the above-mentioned list, it is evident that post-independent era, there has been no comprehensive policies to integrate or implement storm water management system, which is a major component of BGI.

Challenges and Gaps in policy implementations

- One of the significant challenge is the lack of awareness and understanding advantages of blue-green infrastructure among policymakers, government officials, and the public. This leads to limited support and commitment to implementing such policies.
- Fragmented governance structure with multiple agencies responsible for various aspects of urban development and environmental management. The lack of coordination and integration among these agencies is also a major hindrance.
- Implementing BGI requires technical expertise in areas such as hydrology, landscape architecture, and urban planning. However, there is a shortage of professionals with the necessary skills and knowledge to design and implement such projects.
- Limited financial resources and competing priorities often result in inadequate funding allocation for these initiatives.
- BGI requires ongoing maintenance to ensure its long-term sustainability often a lack of clarity regarding the responsibility and funding for maintenance, which can lead to the deterioration of infrastructure over time.
- The mentioned policies in the above section are implemented with multiple measures in a single frame, also they fulfil the regulatory framework on an individual resource palette but not as an integrated resource for BGI. There are discrepancies, gaps, and conflicts in ongoing policies related to environmental policies, water policies, etc. For the integrated approach of the BGI, a participatory approach is needed to develop policy implementation. Figure 1. When it comes to complicated issues with a high level of ambiguity, the distance between the government's intentions and the tools utilized in policy execution might increase over time, resulting in an increasing mismatch.

Comparative Analysis between Global and Indian Policy & Initiatives

Comparative analysis of policies related to global and Indian context has been done on the basic key aspects that are important for policy implementation measures.



**Ananya Tripathi and Subhrajit Banerjee****overlapping global and Indian aspects of BGI implementation**

Global policies for blue-green infrastructure must be customized and localized for the Indian context, taking into account India's particular difficulties, cultural diversity, and socioeconomic circumstances. Concerning the local context, Different regions of India have different climates, topographies, and population concentrations. Policies should take into consideration these variations and be flexible enough to be applied in urban, peri-urban, and rural settings. About the current scenario, talking about the "green cities- a Sustainable Urban Future in Southeast Asia", a Technical Assistance document from ADB, guidelines for preparing a Green City Action Plan is provided, whereas similar guidelines and proposals are developed for a Green and blue Master Plan for the city of Bhopal. (Bhopal Smart City Development Corporation). Similarly, the sponge city concept has been adopted in India for flood control from the best practice of Wuhan, china. overlapping of global policies and framework onto the Indian context is adding value to the cities which are facing the same problem that the global cities have faced but one should take into consideration the similar geographical and climatic context as well as the stakeholder engagement, and future monitoring of policies which makes it a successful model of global policies related to BGI because implementing infrastructure is not difficult but to maintain it is a challenging task.

Parameters

By taking these factors into account, Indian and global policies have common goals and methods for every aspect of blue-green infrastructure Major parameters include flood resilience, storm water run-off, surface run-off, urban heat islands. Taking the reference of best practices and policies based on similar parameters, to overlap the policy initiatives needs local context, the character of the city, and its behavior. Referring to the case of Rotterdam, Netherlands the major parameter taken into consideration for BGI was the reduction of floods and the cases of drowning that essentially counter the problem and has been a successful model for flood resilience. Similarly, if we notice the case of Bengaluru, 2023 some parts of the city has been recently flooded due to the incapable storm water drainage and even the cases of flooding have extended to the extent of drowning resulting in the loss of life and collapsing of the entire building was despite new storm water drainage plan implemented by the city authorities. For the Indian context, it is essential to adopt the practices from the global context considering their parameters but the amalgamation of the city character, its typology, and context is necessary for any intervention of such policies

Individual /Sectoral Plans

Almost every city in India has a stormwater drainage plan which has specifications of the initial stage of the inlet of stormwater and the final discharge of water in the river or canal. But the idea of reuse, recharge, and harvest which is a sustainability measure for a city is missing in many of the implemented plans. The lack of established guidelines and policies requiring the inclusion of reuse and recycle principles in stormwater drainage designs might be a barrier. It is difficult to drive required changes and assure compliance if policies and regulations are not in existence or are not successfully implemented. Overlapping a case of ABC water program in Indian context, there is a need for making guidelines for stormwater runoff standards taking reference with the model.

Implementation Procedure

Every effective blue-green project featured a significant level of community involvement, like in Newcastle, UK. Initiatives in Bengaluru and Madurai, India, have also involved a significant amount of public participation. The general understanding of blue-green projects will be improved through active engagement with government, planners, policymakers, and other political representatives, foster ownership in the creation, formulation, implementation, and oversight of such activities.

Gaps in Coordination

Mapping global policies into the Indian context may face limitations due to data and information gaps. Accurate and up-to-date data related to the environment, land use, population dynamics, and socioeconomic factors are crucial for effective policy adaptation. Awareness among the stakeholder and a multidisciplinary approach must be done as, India's vast size and diverse regions pose challenges in obtaining comprehensive and reliable data, hindering the adaptation process.





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CONCLUSION

Development of Indian policies related to BGI can create new opportunities for the implementation of nature-based solutions in cities. Comparative analysis suggested that India has many ongoing sustainable policies that can be relevant to the BGI but that need to be collaborative and bring different multidimensional departments into the same umbrella. The collaborative efforts of policymakers, researchers, professionals, and local populations are key to the development of blue-green infrastructure in India. It requires concerted effort, efficient governance, and the inclusion of several stakeholders. India can achieve sustainable development, improve urban resilience, and create a healthier and more liveable environment for its population by adapting global policies to the Indian context. Global policies serve as a basis for sustainable development and "blue-green" infrastructure as a whole must be customized to the Indian context by taking into account the demands of the nation, as well as local government systems, socioeconomic considerations, and environmental conditions. India should create contextual policies that address its particular difficulties and possibilities by coordinating global goals with national priorities. This will enable the creation of more efficient and inclusive blue-green infrastructure across the entire nation.

Recommendations for enhancing BGI implementation in India

BGI is acknowledged on a global scale for its numerous environmental, social, and economic benefits it suggests that policy and practice need to change to better implement BGI and make it multifunctional rather than being primarily focused on managing flood risk and only mentioning broader benefits in passing. BGI cannot be structured to provide all possible benefits simultaneously, many cities are likely to prioritize enhancing quality of life through high-quality BGI. Indian cities perspective, BGI design will be influenced by the geographic, climatological, socio-political, and governance features of cities, guided by each city's priorities and strategic objectives, and negotiated by the stakeholders involved in BGI projects to maximize benefits and determine which benefit trade-offs will be made. It will be beneficial if we can implement BGI during the construction phase of other infrastructure projects. Annual environmental status reports containing information on natural characteristics and pollution indicators are published by numerous Indian cities. To set reasonable expectations, such actions must be included when conducting an annual blue-green audit for all communities. Governments must uphold uniform statutory terminologies and definitions and carry out the complete integration of all urban plans and documents that highlight environmental elements to streamline processes and ensure the integrity of the original blue-green canvas. Such a framework will provide a certain uniformity for parastatal agencies-incorporated initiatives, and local project initiatives as well.

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Table 1. Table elaborating the major policies related to the best practices in global context

S.No	Project	City, country	Population	Parameters for BGI	Individual/sectoral plans	Policy & Implementation Procedure
1.	Blue-Green Cities Research Project	Newcastle, UK	280,000	Flood resilience	Newcastle City Strategic Surface Water Management Plan	partnership between Newcastle City Council, the Environment Agency, and Northumbrian Water (private water and sewerage company) Stakeholder participation
2.	Grey to Green Initiative,	Portland, US	653000	Flood reduction, water quality improvement(e.g., by CSO reduction)	Portland Watershed Management Plan (2005)	Portland, Oregon U.S storm water management manual
3.	Blue-green grid initiative	Rotterdam, Netherlands	623000	Climate change resilience Drowning	Rotterdam Climate Proof Programme (2008), the Rotterdam Adaptation Strategy (2013), Resilience Programme (2014), and the Water Sensitive Rotterdam Programme (2015).	PPP, public participation
4.	Active, Beautiful, Clean Waters Programme	Singapore	5690000	Storm water run-off Surface runoff Green spaces (primary potential)	Implemented through a master plan, water design guidelines (2009)	Guidelines implemented through Drainage Handbook on Managing Urban Runoff by Public Utilities Board & Ministry of Environment and Water Resources The ABC Waters Certification scheme launched by PUB
5	Sponge city programme	Wuhan china			The National New-Type Urbanization Plan (2014–2020), Urban Climate	The finance ministry gives funding to identify fundraising





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					Change Adaptation Action Plan (2016)	strategies based on an assessment index system based on national guidelines
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Table 2. Showing the comparative analysis between global and Indian policy & initiatives with key aspects

Key aspects	Global context	Indian context
Policy Frameworks	International frameworks have strong emphasis on sustainable infrastructure and environmental preservation include the Paris Agreement, the Sendai Framework for Disaster Risk Reduction, and the Sustainable Development Goals (SDGs) of the United Nations. It has its regulations and policies, as well as universal guidelines.	The National Action Plan on Climate Change, Smart Cities Mission, National Water Policy, and Swachh Bharat Mission are policy frameworks in India that address parts of BGI and urban sustainability but are not directly implemented.
Local Context and Adaptation	Global policies give broad recommendations and best practices that must be modified for specific contexts and scales. They advise countries to analyze their individual requirements, priorities, and capacities when it comes to implementing BGI.	Adapting global policies to the Indian setting involves account variables such as different climatic zones, cultural preferences, socioeconomic gaps, and urbanization characteristics. Policies are not prioritized at an inclusive level.
Institutional Framework	Global policies often promote international collaboration, knowledge sharing, and capacity building to support the implementation of blue-green infrastructure.	India has a decentralized governance structure, involving multiple stakeholders, from national to local levels. The implementation of BGI policies requires coordination between various ministries, departments, and local bodies. Collaborative approaches involving government agencies, community organizations, and private sector entities are crucial for effective implementation.
Financing and Resource Mobilization	Global policies emphasize the need for financial resources, technology transfer, and innovative financing mechanisms to support sustainable infrastructure development.	India faces challenges in mobilizing adequate funds for BGI projects. The government encourages public-private partnerships, international collaborations, and leveraging climate finance mechanisms to bridge the resource gap. Efforts are being made to promote green financing, including sustainable bonds and impact investments.
Data and Information Systems	Global policies emphasize the importance of reliable data, monitoring systems, and evidence-based decision-making to assess the effectiveness of blue-green infrastructure.	India is working towards strengthening its data and information systems to support evidence-based policy formulation. Improving data collection, management, and sharing processes is crucial for monitoring and evaluating the impact of blue-green infrastructure initiatives.





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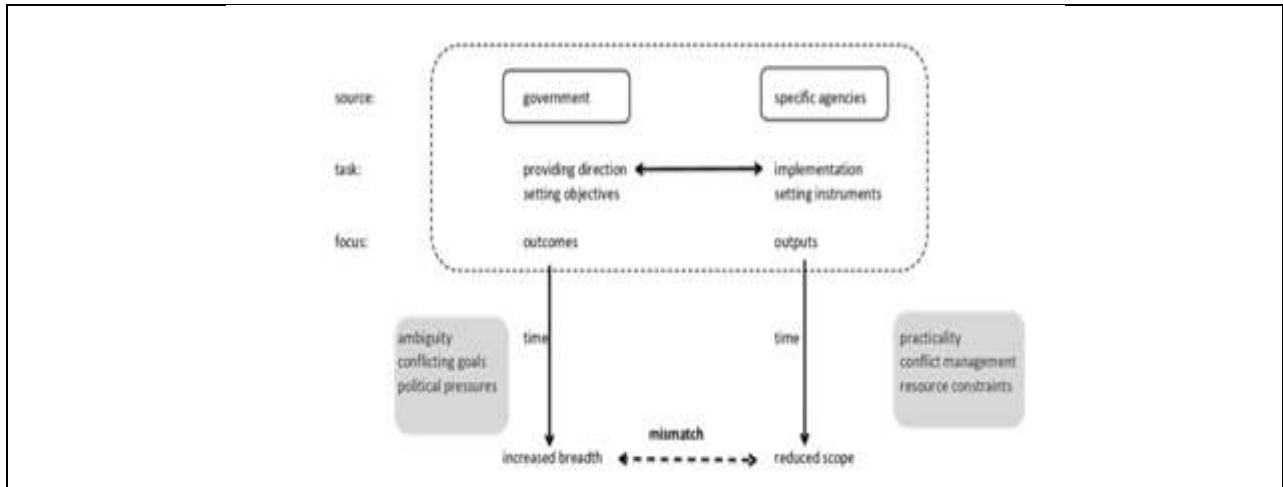


Figure 1. A framework explaining the gap between policy aspirations and implementation[41]





Integration of Solar Technology with IoT solutions using Holographic Tech for Eco Entrepreneur's

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ABSTRACT

The advanced IoT-based super car model integrated with a Fresnel Prism-based Solar Energy system provides the feature of enabling the car to operate without any emissions. The following method called Δx is for the analysis, which is the difference between the temperature and the intensity of the sunlight, which in fact reduces the use of fossil fuels to a great extent, hence reducing the carbon emissions and finally aligned with the Sustainable Development Goals. The car is equipped with inbuilt solar panels of between 1.35 to 2.62 square feet each, that consist of Photovoltaic (PV) cells that are engineered to increase the absorption of sunlight to more than 25%. It also included a battery of 90 to 200 volts that consists electrical energy transformed into mechanical, thus making the car have additional solar 450. The vehicle is designed to process solar panels from 2.0 to 4.5 square feet, which generate from 15 to 48 km of electricity daily at speeds between 25 to 45 km/h, reducing the need to lean on a conventional charging station. This integration of prism lenses, solar cells, energy storage, and basic IoT solutions for performance tracking, speech recognition, and navigation will help in integrating mobility features directly into the car. The solar automobile market is expanding quickly as environmental concerns push consumers and venture capitalists toward sustainable transportation options. The possibility that vehicles could work on a large scale with little or no need for extensive charging is appealing both personally and commercially. There exists great potential for green entrepreneurship in this sector, given that there are many opportunities to startup companies that deal with solar cars. At such times when technology is changing at a rapid pace and a huge number are getting inclined towards sustainability, this unification of solar energy with the ML/Artificial Intelligence and holographic solar panels in vehicles has claimed to





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presage an unbeatable game-changer in the coming future of transportation. New frontiers are opened up for salient entrepreneurial enterprise.

Keywords: Free Emission Operation, Energy Independence, Sustainable Transportation, Cost Savings, Prism Photovoltaic Cells, and Holographic Panels.

INTRODUCTION

The depletion of the crude oil resource is now a more heated debate as it involves political forces, industry players, and researchers. The burning need to find other sources of energy has become very imperative with the depletion of the conventional oil sources. Most solar-cars are wholly powered by the photovoltaic cells that convert sun rays into electrical energy, which powers the car's motors. These vehicles are often called "green" because they produce no greenhouse gases during operation. The electric power supplied by the photovoltaic cells can be conserved in batteries, and the DC motor is supplied with this to provide the kinetic energy of the vehicle. Solar vehicles have faced many obstacles, however. This low energy development by solar panels is a significant limitation, driving these vehicles mostly to require alternatives such as batteries or generators for proper functioning on extended trips. These panels have variable efficiency and do not succeed in generating the necessary power in sites where sunlight is reduced. The designed electric solar vehicle is quite complicated for the particular characteristics and systems regarding the management of energy that guarantee optimal workings under different conditions. For instance, using Fresnel Prism lenses, the intensity of sunlight that hits the plates can significantly influence the speed at which the battery will be charged. While the more direct sunlight is at its peak during midday, better charging performance is produced. This can raise the level of efficiency, but, at the same time, in the staff's device with an off-grid principle, the damages due to fluctuations in temperature have to be avoided by having the design in place with thought given to aspects such as a cooling system and trackers. Also, the financial cost of solar technology still remains prohibitive, though the price of photovoltaic cells has plummeted deliberately throughout the recent years. This all implies that new technology and design of the holographic solar panels, Fresnel prisms or lenses, and IoT integrations for these cars have to advance to make them more practicable and affordable for the masses with this growing size of the market. An International Energy Agency report states that with the present oil production capacity, a significant amount of it needs to be replaced by 2030 just for remaining at the current level; hence addressing oil depletion is very much important. Transition is necessary from traditional oil to alternative energy sources. With out good investment in renewable sources of energy in the context of "Green Eco Entrepreneurship" and in energy efficiency, the rate of decline of oil production might result in unimaginable repercussions in the global economy .

Expensive production and low output: |Special Parts|: Solar-powered cars require very complex photovoltaic (PV) panels and other special parts. They are thus expensive to produce. In these modern times, solar vehicle costs range between \$17,500 and \$100,000 on average, well above the cost of regular cars.

Challenges from Technology, Efficiency, and Environmental Factors: Solar panels on vehicles are still quite ineffective, usually 13.65% and 24.55 % at their very best.

METHODOLOGY

Components of solar powered automobiles

Solar vehicles benefit from a plethora of components, which makes it possible to harness solar power to the maximum, convert it into a usable form of energy, and provide for motion. Key components in our solar vehicle, along with a very short description of their role, are enumerated below:





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Solar Panel Fresnel Prisms

Play: Converts light from the sun into electricity by the photovoltaic effect of photons and electrons. The cells are rated at 200W power, 24V voltage, and dimension >2.0, 3.0 feet. They capture sunlight and change it into electrical energy.

Lead-Acid Batteries

What the component does: It stores the electrical energy produced by the solar panels for use at a different time.

DC Series Electric Motor: What the component does: This converts the electrical energy from the batteries into mechanical energy, which later leads to impulse driving of the vehicle by use of a belt drive system *Power-6500W 1 Horse Power Speed-2600-1440 rpm voltage- 24v current-100Amp.*

Charge Controller

Function: Manages voltage and current from the solar panels streamed to the batteries.

AC/DC Power Converter

Function: Serves as a power electronic interface which, if required/necessary, will adjust the DC output.

Energy Management System

Description: The energy management system actively and efficiently manages the distribution of energy between batteries, solar panels, and the motor. It is adaptive and would be able to accommodate any changes going on, for instance, a good sunny day.

Super solar car Design Model: When combination in a solar car, they allow the solar vehicle to tap into and unlock the potential of the renewable energy used within it. We have elevated this solar energy utilization to an all-time high with the employment of F prisms and lenses in combination with IoT energy management. These vehicles have represented one of the greener and safer vehicle replacements ever to fossil fuel-based traditional transportation. Further developments and deployments of IoT technologies, along with mass production, will improve affordability and performance.. The solar module is used with the output range from 24V to 25V.

RESULTS

We read through a number of techniques, and these are the key issues that we highlighted

IoT Integration: IoT technology applied in solar-driven battery electric vehicle to strategically monitor and control. These EVs independently recharge themselves through solar power, and with the help of IoT technology, they further optimize it for effective performance and efficiency. IoT-enabled features: - Real-time monitoring, follows the real-time monitoring of critical variables such as battery charge, solar panel output, and energy consumption through sensors and IoT devices to provide instantaneous data.

Predictive Maintenance: The IoT system will aggregate data to determine potential issues and plan maintenance.

Bifacial Fresnel-Design Prism: Prism-designed solar panels are capable of trapping light beaming upon the two sides of cells and hence able to produce *35% more energy* when compared to its conventional peers.

Holographic Tuning: They filter the sun's energy through a single sunlight wavelength and



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expose it on solar cells to remain at their optimal performance at any level of concentration. This spectrum selection keeps the cells operating at or near the peak performance, temperature, even at 3X-3.5X concentration.

Material Innovation. The creation of flexible and semi-transparent solar cells improved the look of solar cars and the ability for the technology to work efficiently. The means of such materials enable a significant level of integration to the designs of vehicles with no significant loss to the capture of energy.

Vehicle Design and Performance. The need for light and low-weight designs for efficiency. This includes models that can reach speeds of 75-80 km/hr while keeping a low drag coefficient.

Energy Management Systems: A stride in the incorporation of IoT tracking systems, providing the very best use of solar paneling power under whatever condition.

Sustainability and Environmental Benefits: Solar cars shall be able to bring radical cuts in carbon emissions. E.g., On an average, a solar car can save up to 280 kg of CO₂ emissions annually, providing a cleaner environment for cities. Below are a number of key insights from studies related to improving the effectiveness of solar-powered vehicles

Aerodynamic optimization: Our advanced solar car has helped us a great deal in getting insight into the optimization of shape in solar vehicles for better aerodynamics.

Cutting out drag; the force an automobile meets while in motion moving through the air. This will reduce drag, the more force that the vehicle faces and will need more energy to fight against it to keep moving—more of the solar panel energy being consumed for this purpose.

Minimizing Flow Disturbances: The aim of aerodynamics design is to retain the air in stream with the vehicle surface, thereby avoiding it being detached from the surface, thus creating turbulence and increasing drag.

Improve Energy Utilization: Shaping the vehicle in a manner that allows better airflow helps engineers ensure that more energy can be put into forward motion, rather than being completely spent in turbulence. As a matter of fact, industrialization should be based on aerodynamic design and streamlined shape in the making of a solar vehicle that would be efficient in operating.

DISCUSSION

Aero dynamics: Driving ability vs Vehicle hasten & Simulated solar radiation VS Temperature

One major benefit of integrating IoT into this equation would be the possibility of collecting and analyzing incoming data at runtime. The IoT devices are always working on essential parameters, e.g., the amount of energy produced by solar panels, battery condition, and environmental conditions.

Performance improvement – The performance of solar panels and parts of a vehicle can further be fine-tuned to boost energy efficiency by checking the pattern usage of energy and the conditions of the environment. IOT technology enables more effective management of energy in solar-powered cars.

Better User Experience: Real-time monitoring and control provide updates on how the car is driving, battery health, and when and how much energy is actually required. This visibility will therefore help the user make more precocious judgments on his or her energy use and travel plans. the increasing efficiency and performance of Fresnel Prism-the primary ways in which IoT plays a role in





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Real-time Data Tracking: IoT systems allow the continuous monitoring of various parameters related to solar panel performance including.

Energy Production: The sensors attached to the solar panels keep track of real-time energy output, which enables the user to assess the effectiveness of their solar energy system.

Performance Improvement: The conjunction of IoT allows adaptive control of solar panels based on environmental parameters.

Variable Adjustments: The orientation or angle of solar panels can be adjusted to get more sunlight, based on changed real-time weather conditions and sunlight strength.

Remote Access and Control: IoT technology allows provision of any desired place access and control by customers on their solar panel system.

Software: Users can always monitor performance and health with their solar panels from any place through the mobile apps. This means swift interventions can be made into the occurrences of problems like system failure or debris buildup.

Alerts and Notifications: The IoT system alerts the user of drastic changes in performance or potential problems, thus offering an opportunity to act in urgency in mitigating the problem.

Continuous Monitoring: These devices make it possible to keep track of key factors, such as energy production, at all times. Real-time data evaluates if the efficiency of solar panels is good enough and drives them towards their optimized performance.

Data-Driven Decision Making: Massive volumes of data made available through IoT enable effective decisions such as:

Trend Identification: Analyse the patterns of energy consumption to make adjustments leads to better efficiency and reduced costs.

Performance Insights: Elaborate analytics on how to increase the performance of the solar panels and battery allow much better overall efficiency of the vehicle.

CONCLUSION

Applying IoT to solar-powered EVs with better maintenance, energy management, user experience, and informed decision-making results in efficient and sustainable transportation.

A. Reduce Operating Costs: IoT solutions result in significant reductions of the operating costs of solar-powered EVs.

B. Reduces the Cost of Energy: Through the use of solar to charge your electric vehicle, there is less reliance on the grid's electricity, which is costly many a time.

C. Maintenance Savings: IoT-enabled predictive maintenance provides for advanced prediction of potential issues, thereby saving costs involved in too many repair works and minimizing down time

D. Great Mining of Economics: IoT technology infused into this solar-based EV results in an immensely high rate of return in savings.

E. Better Charging Operations: Charging could be done in a better and efficient way through the features of IoT solutions by the means of better charge-management functions, time optimization of energy inflows, duration reduction.

G. Long-term Investment Returns: Long-term monetary returns by investments in solar EVs installed with IoT technology.

H. Cost Neutralization: The commencing investment in solar panels and IoT systems can be balanced with long-term fuel and maintenance cost savings. It is depicted through research that the total related expenses in owning a vehicle over its lifetime can be minimized to a great extent, hence an economically rational plan. The economic impacts of integrating IoT technology gives better return on investment over time. Further, converting solar energy into usable power is yet too inefficient, between 16.5% and 17.5%. Problem can be rectified by using Fresel prism lens which is very efficient and boosts solar cells to around 30-35%. These challenges shall be circumvented as research in this arena gets more developed. Electric vehicles with solar power integration are a big market opportunity, and these





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should be introduced to our daily lives aiming to meet the Sustainable Development Goals for OE (Organizational Excellence) and ESG (Environmental, Social, and Governance). The real question that arises: Why and how to go about it in research or practical applications.

Future research or applications need to be focused on Prism Solar Technologies: As they have manufactured novel bifacial solar panels with the holographic tuning technique for high efficiency and low costs. The defining characteristics of the novel Prism-based PVC solar panels are refraction and light concentration. When light enters a prism, the phenomenon of refraction occurs. This results in bending the light towards the normal for the reason of the shift of the medium from air to glass. Such bending can have the effect of focusing more light in an area through which it has travel after passing through the prism, concentrating more energy in a particular area. The temperature of surfaces can be raised through concentrated energy generated by incident reflected or refracted light falling upon them. The dispersion of light occurs when sunlight passes through a prism, splitting it into its constituent colour, forming a spectrum. It is observed that various energies correspond to various wavelengths of light. Thermal measurements have shown that if a thermometer was placed exactly where the spectrum is projected, it would record a temperature increase. A few degrees difference in temperature will most likely show evidence of this reflected light if you place a thermometer in the chosen spot. A recommendation is to use Fresnel Prism Lenses that are more than twice the thickness of PVC. The panels use holographic tuning technology- the holographic optical components divert certain wavelengths of sunlight onto the solar cell. "Spectral selection" thus performs the magic of letting the cells work at or near their optimal temperature efficiency, all this despite a concentration dynamics of $3X-3.5X$: the total sun energy production is roughly *10000 times* more on earth as compared to what is needed for supplying power for all human beings present around the world. By employing holographic film to the materials selection, Prism Solar panels are able to reduce the use of costly silicon by 50-75%, cutting on material expenses in their silicon without losing any much-needed efficiency by spectral tuning. Holographic tuning improves the performance of Prism Solar panels by optimizing light absorption via Fresnel prisms, ensuring more collected energy from both the front and rear sides of the panels, material saving, and enable reliable and repeatable operation. The prism-based, bifacial PVC panels from Prism Solar make its solar energy production more economical and effective, all the more with a focus and high-quality design integration to focus on the innovation of holographic tuning and integration with Internet of Things (IoT) system. Solar technology-designed vehicles drive demand for sustainable products and businesses that are targeting environmentally concerned customers, thereby ratcheting sustainable demand across the ESG sector. New research would pertain to products such as solar backpacks, solar pens, and solar umbrellas, contributing toward changing consumer behaviour serving both B2B and B2C purposes. The B2B Companies, who are the customers for the development of solar cars, would show a sense of environmentalism and contribute to expanding the market for solar cars after 2026.

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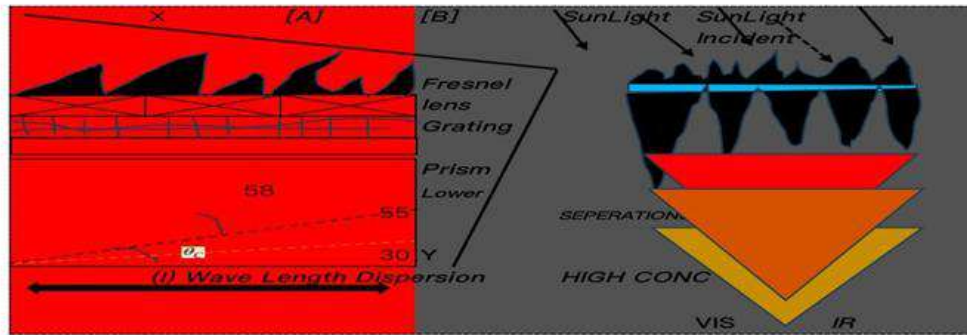
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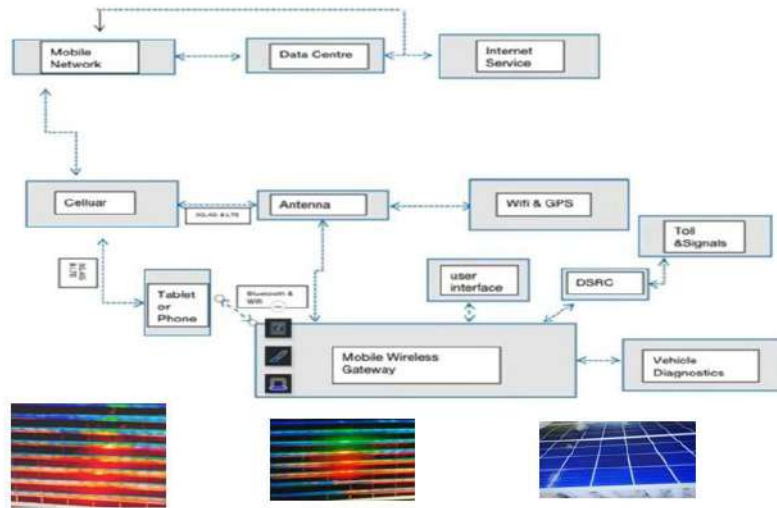


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of photonics for energy., Solar factsand advices, Photopolymer holographic lenses for solar energy, Development of aerodynamics for a solar car., IEA International energy agency., etc.



PIC1 | Prism 1 | Pic 2 | Prism 2



Holographic Pic 1

Holographic Pic 2

Holographic Pic 3

PIC 1 (Main design)

PIC 2



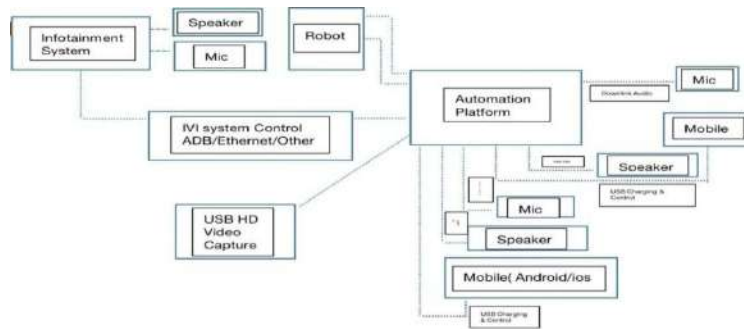
PIC 3

PIC 4

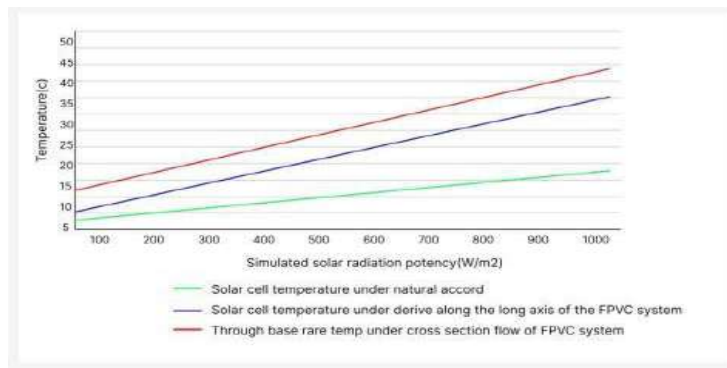
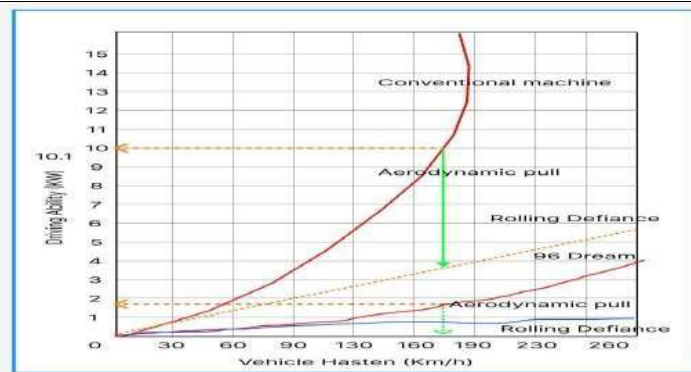




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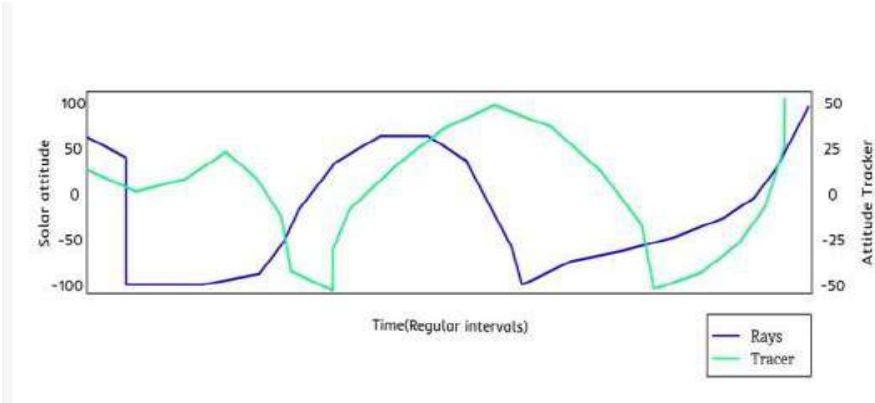


IOT (POWERTRACKER)





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Time Intervals vs solar altitude & Cleft No Vs Prism degree



Other mechanical parts of Super solar car





Survey on Plant Diseases Detection Deep Learning and CNN”

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ABSTRACT

This survey aims to provide an overview of recent advances in plant disease detection using machine learning (ML) techniques, particularly deep learning, and convolutional neural networks (CNNs). With the growing demand for sustainable agriculture and increasing concerns about food security, timely and accurate diagnosis of plant diseases has become essential. Traditional methods of plant disease detection, such as visual inspection and laboratory testing, are time-consuming and labor-intensive. In recent years, ML-based approaches have shown great potential in automating the detection of plant diseases, which can significantly improve disease management and reduce crop losses. This survey discusses various ML-based methods and their applications in plant disease detection, including feature extraction techniques, image classification algorithms, and transfer learning. Furthermore, the challenges and future directions of this field are also discussed, highlighting the need for more comprehensive datasets, better training strategies, and more robust and interpretable models.

Keywords: Plant diseases, Convolutional Neural Network (CNN), Deep Learning, Feature Extraction

INTRODUCTION

Plant disease detection is an important task in agriculture, as plant diseases can cause significant damage to crops and reduce crop yields. Traditionally, plant disease detection has been done by visual inspection by experts or by chemical analysis, both of which can be time-consuming and costly. However, with the advent of computer vision and machine learning techniques, it has become possible to automate the process of plant disease detection using image analysis. Convolutional neural networks (CNNs) have shown promising results in plant disease detection, as they are able to learn complex features from images and classify them accurately. By training a CNN on a large dataset of plant images with known disease types, the model can learn to identify characteristic features of different





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types of plant diseases, such as leaf spots, discoloration, and deformation. Once the CNN is trained, it can be used to analyze new plant images and identify any diseases present. This automated approach to plant disease detection has the potential to save time and resources, as well as improve accuracy compared to traditional methods. The paper also provides a critical evaluation of the current research in this area and identifies several key research directions for future work. These include the development of more robust and accurate CNN models, the integration of multiple sources of data, such as spectral and thermal imaging, and the development of real-time applications for automated plant disease detection. The paper provides a valuable resource for researchers and practitioners in the field of plant disease detection using CNNs, highlighting the key challenges and opportunities for advancing the state-of-the-art in this important area of research.

Overview of disease detection using CNN

CNN-based plant disease detection is a popular application of computer vision technology in agriculture. Convolutional Neural Networks (CNNs) are a type of deep learning algorithm that can effectively classify images by learning from a large dataset of labeled images. To build a plant disease detection system using CNNs, the first step is to collect a dataset of images of healthy and diseased plants. These images should be properly labeled and annotated to train the CNN model. The dataset should be diverse and large enough to capture various types of diseases and variations in plant appearances. The next step is to train the CNN model using the labeled dataset. The CNN model learns to classify plant images as healthy or diseased by analyzing the patterns and features of the images. During training, the model adjusts its internal weights and biases to optimize its accuracy in classifying images. Once the CNN model is trained, it can be used to classify new plant images as healthy or diseased. This can be done by passing the image through the trained model, and the model outputs the predicted class label. The accuracy of the model can be evaluated using a test dataset that was not used in the training phase.

DATASETS

PlantVillage Dataset

This dataset contains over 54,000 images of healthy and diseased plant leaves. The dataset covers over 38 plant species and 26 diseases.

PlantDoc

This dataset for visual plant disease detection. The dataset contains 2,598 data points in total across 13 plant species and up to 17 classes of diseases, involving approximately 300 human hours of effort in annotating internet scraped images.

New Plant Diseases Dataset

This dataset consists of about 87K rgb images of healthy and diseased crop leaves which is categorized into 38 different classes. The total dataset is divided into 80/20 ratio of training and validation set preserving the directory structure. A new directory containing 33 test images is created later for prediction purpose. The other data sets included in Kaggle are **Tomato Disease Dataset**, **Grape Disease Dataset**, **Potato Disease Dataset**, **Cassava Disease Dataset**, **Apple Disease Dataset**, **Citrus Disease Dataset** These datasets are often used to train machine learning models for plant disease detection, which can then be used to identify and classify diseases in real-time.

Convolutional Neural Networks (CNNs) based feature extraction

Traditional feature extractors can be replaced by a Convolutional Neural Network(CNN), since CNN's have a strong ability to extract complex features that express the image in much more detail, learn the task specific features and are much more efficient.

SuperPoint

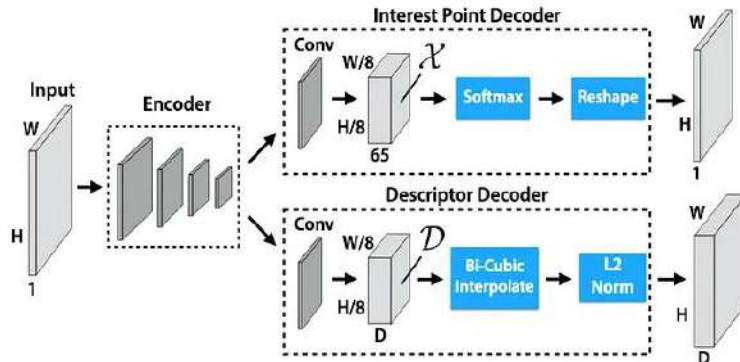
Self-Supervised Interest Point Detection and Description – The authors [1] suggest a fully convolutional neural network that computes SIFT like interest point locations and descriptors in a single forward pass. It uses a VGG-style



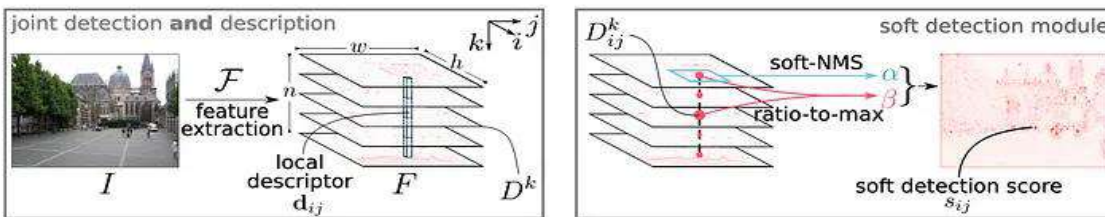


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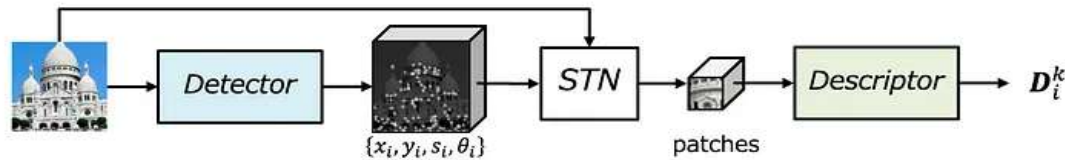
encode for extracting features and then two decoders, one for point detection and the other for point description.



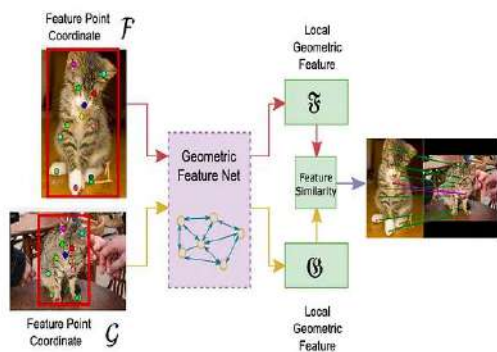
D2-Net: A Trainable CNN for Joint Description and Detection of Local Features – The authors[2] suggest a single convolutional neural network that is both a dense feature descriptor and a feature detector.



LF-Net: Learning Local Features from Images– The authors[3] suggest using a sparse-matching deep architecture and use an end-to-end training approach on image pairs having relative pose and depth maps. They run their detector on the first image, find the maxima and then optimize the weights so that when run on the second image, produces a clean response map with sharp maxima at the right locations.



Deep Graphical Feature Learning for the Feature Matching Problem – They[4] suggest using a graph neural network to transform coordinates of feature points into local features, which would then make it easy to use a simple inference algorithm for feature matching.



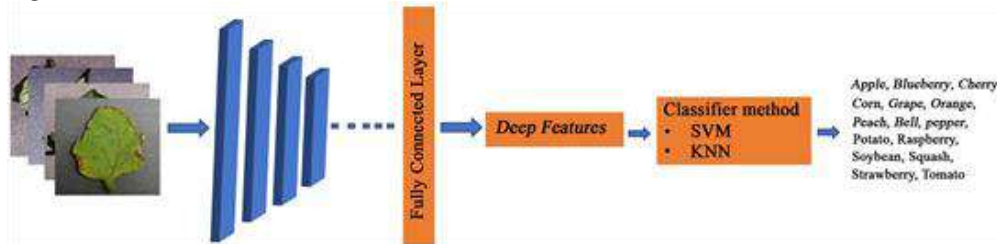
Deep Feature Extraction and Transfer Learning:[5] The techniques used were transfer learning as well as extracting features on various layers in the network. Later, the extracted features, as well as transfer learning were classified



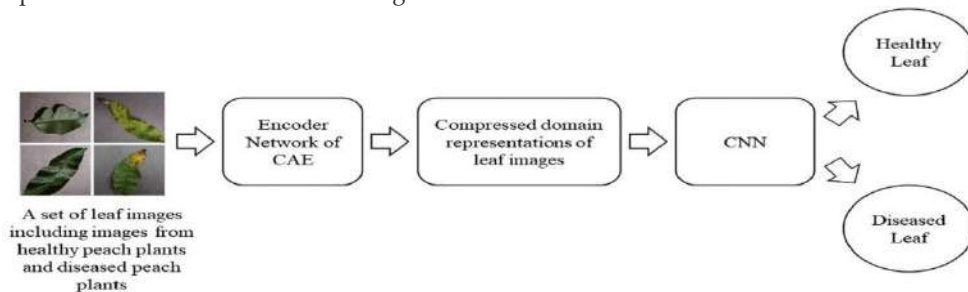


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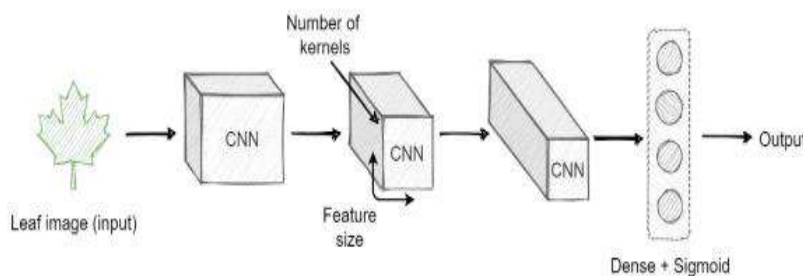
using Support vector machine and K-nearest Neighbor, their time of execution, F1 score, True positive and the True negative are determined.



Hybrid Feature Extraction techniques with ANN and SVM classifier: This paper [6] studies the use of deep-learning models (AlexNet, VggNet, ResNet) pre-trained on object categories (ImageNet) in applied texture classification problems for plant disease detection. In this paper [7], a novel hybrid model was proposed for automatic plant disease detection that was based on two Deep Learning techniques named Convolutional Autoencoder (CAE) network and Convolutional Neural Network (CNN). The proposed hybrid model first obtained compressed domain representations of leaf images using the encoder network of CAE and then used the compressed domain representations for classification using CNN.



In this research [8], authors propose a novel scheme for the detection of plant leaf diseases using deep convolutional neural networks (DCNN). From the segmented images, features are extracted using grey level co-occurrence matrix (GLCM). Dimensionality reduction of features is performed using principle component analysis (PCA). Finally, classification is done using a novel DCNN architecture. In this paper [9], the deep learning model's architecture namely, VGG16 and InceptionResNetV2, are used to train the model. These models are primarily made of convolutional layers. In this paper [10], The experimental results validate that the Xception and DenseNet architectures perform better in multi-label plant disease classification tasks.



The authors [11] proposed a trilinear convolutional neural networks model using bilinear pooling (T-CNN) for disease identification and use 3 CNNs, VGG-16, Inception v3, and ResNeXt-101, as the base networks for the model. The authors [12] proposed a novel deep convolutional neural network model, namely, the Dense Inception convolutional neural network (DICNN). Deep separable convolution is first used by DICNN to build the first two convolutional layers to reduce the number of parameters and prevent the overfitting problem of the model.





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Challenges

CNN-based plant disease detection has made significant progress in recent years. However, there are still some challenges that need to be addressed to improve the accuracy and efficiency of the detection system. Here are some of the challenges:

Limited and Unbalanced dataset

In the case of plant disease detection, collecting a large and diverse dataset can be challenging, especially for rare or new diseases. Another challenge in plant disease detection is the class imbalance problem, which occurs when the number of samples in one class is significantly higher than the other class.

Quality of imaging

Illumination changes, shadows, and occlusions can all affect the quality of the image, which can lead to false positives or false negatives.

Similarity between healthy and diseased plants

Some plant diseases can be difficult to detect because the symptoms are not easily visible, or they may resemble symptoms of other diseases or even healthy plants.

Computational complexity

Deep learning models require significant computational resources to train and test, which can be a challenge, especially for resource-constrained devices like mobile phones and embedded systems.

Further improvements

Convolutional Neural Networks (CNNs) have shown great promise in plant disease detection, and there are several future enhancements that can be made to improve their accuracy and efficiency:

Integration of multi-modal data

CNNs can benefit from combining data from different sources such as hyperspectral imaging, thermal imaging, and 3D imaging to improve the accuracy of disease detection.

Transfer learning

Transfer learning can be used to transfer knowledge learned from one domain to another. Pretrained models can be used to train a CNN for plant disease detection.

Data Augmentation

Data augmentation techniques such as rotation, flipping, and cropping can be used to increase the size of the training dataset and improve the robustness of the CNN.

Ensemble methods

Ensemble methods can be used to combine the predictions of multiple CNNs to improve the accuracy of disease detection.

Real-time detection

Real-time detection can be achieved by using lightweight CNN architectures, pruning techniques, and hardware acceleration.

Domain adaptation

Domain adaptation can be used to transfer the knowledge learned from one crop to another, which can reduce the need for large, labeled datasets.





CONCLUSION

Based on the survey conducted on plant disease detection using CNN, it can be concluded that CNN has proven to be a promising technique for the accurate and efficient detection of plant diseases. Most of the respondents have expressed their satisfaction with the performance of CNN-based models for detecting plant diseases. Additionally, the survey revealed that the accuracy of the CNN models is influenced by various factors, including the quality of the dataset, the size of the dataset, and the architecture of the model. To ensure optimal performance, it is important to carefully select these factors and optimize the CNN models accordingly. Overall, the survey results suggest that CNN-based models have great potential for the effective detection and prevention of plant diseases, which can significantly improve crop yields and ensure food security.

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Antimicrobial and Wound Healing Properties of an Available Synthesized Silver Nanoparticle from *Mentha piperita* Plant Extract, and Encapsulation in Chicken Collagen

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ABSTRACT

Wound-healing activities are inferred in the medicinal plant *Menthapiperita* L. This research focuses on the preparation and incorporation of AgNPs with chicken collagen incorporated with *Menthapiperita* extract for their usage in wound healing and antimicrobial tests. The formation of AgNPs was also, determined by UV-Vis spectroscopy, FTIR, TEM and EDX. The AgNPs shows colour change as expected for SPB as well as the maximum absorbance at 430 nm elsewhere confirming the formation and stabilization of AgNPs. The antimicrobial tests of the collagen-coated AgNPs against *Bacillus subtilis*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Escherichia coli* resulted in zones of inhibition similar to Gentamicin with range of 20 to 22 min, this reveals that the nanoparticles have the ability to inhibit both the Gram positive as well as Gram negative bacteria demonstrating that the nanoparticles can be used as potent antib Vero cell cytotoxicity studies for synthesized AgNPs indicated that the cell proliferation percentage ranges between 89-98% for AgNPs at the concentration of 20, 50 and 100µg/ml. Besides, Chicken collagen not only improved the stability and bioavailability of nanoparticles but also stimulated cell growth and migrated rate to improve the healing process. Untoward effects revealed that these nanoparticles stimulate the vital events of wound healing especially the proliferation phase without showing much cytotoxicity thus supporting the ethnopharmacological use of *Menthapiperita* for skin



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disorders. Therefore, it can be concluded that collagen-encapsulated AgNPs derived from *Menthapiperita* can be further used in the process of creating efficient wound healing agents with enhanced antibacterial efficacy. Successive researches should investigate the in vivo effects in order to assess the healing processes, the doses' elaboration, as well as the nanoparticles' long-term consequences. Furthermore, there is a possibility to expand this green synthesis approach for PTX to the industrial scale, which could potentially result in the development of more effective and eco-friendly wound care treatments in the clinical practice.

Keywords: *Menthapiperita*, silver nanoparticles, wound healing, antibacterial activity, collagen encapsulation

INTRODUCTION

Healing of wound is a complex and an active process from the inception of injury towards the formation of scar tissue, which is a delivery essential armory of human and health domain (Eminget *et al.*, 2014). Since there is an increase in chronic wounds that are adjusted by changes like diabetes, infection, and aging then there is need for efficient and new treatment of these conditions. Standard approaches towards wound care often prove to be inadequate when it comes to complicated wounds, as they do not effectively manage the wound bed, and support proper tissue remodeling and re-epithelialization; therefore, prolonged healing time and higher propensity for infection become the consequences (Eminget *et al.*, 2014). New trends in nanotechnology reveal great prospects in preventing microbial adhesion in biomedical devices through AgNPs; acknowledgeable for its antimicrobial properties and functionalities that can hinder the aggregation of microbes efficiently (Martinez-Zapata *et al.*, 2012). Among them, the utilization of AgNPs in wound healing is particularly interesting because of the nanoparticles' ability to eliminate bacterial contamination, which poses a challenge to the healing of chronic wounds (Martinez-Zapata *et al.*, 2012).

This research seeks to exploit the therapeutic use of *Menthapiperita* that has been used for ages in medicinal practices for various diseases and wound and skin infection. The healing potential of *Menthapiperita* can mainly be explained by the fact that it contains a number of phytochemicals including menthol, rosmarinic acid and flavonoids with antimicrobial and anti-inflammatory properties as well as the fact that wounds were treated with it (Velanet *et al.*, 2009). The preparation of AgNPs using plant extracts can be categorised into green methods as it does not involve the use of toxic chemicals and the phytochemicals are used to reduce metal ions to form nanoparticles and it support the green chemistry norms (Frykberg & Banks, 2015). The synthesis procedure of AgNPs integrated with collagen, an essential protein in the extracellular matrix of connective tissue is believed to improve the stability and biocompatibility of the synthesized nanoparticles mainly because of its significance in offering structural support and promoting tissue repair during the wound healing process (Nunanet *et al.*, 2014). Hence, the encapsulation of nanoparticles in collagen offers great prospects since it can act as a support on which the new tissue can form; using AgNPs, it may enhance the therapeutic effect of these nanoparticles when integrated within the wound site. This research will propose the notion that dispersion of silver nanoparticles blended from *Menthapiperita* extract and chicken collagen and encapsulated chicken collagen provides superior wound healing benefits and taller antibacterial activity as compared to the option of the non-encapsulated silver nanoparticles. The particular aim of this work is as follows; To produce *Menthapiperita* extract mediated green synthesis of silver nanoparticles; To encapsulate chicken collagen on the nanoparticles; and to determine the efficiency of the collagen-coated AgNPs against strains of wounds and their skin repairing proficiency through various in vitro methods.





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METHODOLOGY

Preparation of the extracts

Collection and Preparation of Plant Materials

The leaves of this plant were obtained from mint (*Menthapiperita* L.), manthari (*Bauhinia purpurea* L.), white chaste tree (*Vitexleucoxydon* L.), mehandhi (*Lawsoniainermis* L.), hibiscus (*Hibiscus rosa-sinensis* L.), and Indian mint (*Saturejadouglasii*) grown in and around Chennai, which was taken from perfectly growing plants. The leaves were washed with running tap water to clear the debris and then with distilled water to minimize any contamination. The leaf was then sun-dried for three days after washing with distilled water to prevent destruction of phytochemicals by light and heat. The leaves were then sun dried and ground into a fine powder using a brand-new heavy duty blender commonly used in laboratories. Four grams of the powdered leaves were then required with 100ml of distilled water, and the mixture was placed in a water bath at 55°C for fifteen minutes. After allowing the extract to cool to the room temperature the extract was filtered by Whatman No. 1 filter paper to eliminate any solid particles that may be present and later kept in the refrigerator at temperature of 4°C for the next phase of the nanoparticle preparation.

Synthesis of silver nanoparticles (AgNPs)

Reduction Process

Silver nanoparticles was synthesized using green synthesis procedure by reducing and stabilizing agent using *Menthapiperita* extract. A 1 mM solution of silver nitrate (AgNO₃) was prepared which was then allowed to react with the *Menthapiperita* extract at different concentrations for the enhancement of the synthesis process. After that, the mixture was stirred continuously and heated at 60° C. The reaction progress was judged by an appearance of brown color of the solution from initial pale yellow color due to formation of AgNPs due to reduction of Ag⁺ ions to Ag⁰.

Optimization of Parameters

A number of factors that may affect the size and stability of AgNP were consequently altered in order to assess the effect of these variables on the reaction:

Concentration of Plant Extract

Preliminary studies on the variation of nanoparticle formation were carried out using the 1%, 1.5%, 2%, 2.5% and 3% concentration of *Menthapiperita* extract. The absorbance of the extracts and the identification of the highest value corresponding to the concentration of the extract were made using UV-Vis spectrophotometry.

pH

To the reaction mixture the pH was adjusted with 0.1 N HCl and 0 (zero as in the previous step). 1N NaOH to keep the PH between 5/9. The effect of pH concerning nanoparticle synthesis was endorsed through the absorbance of each developed pH, however pH 8 signified the highest degree of generation and efficiency for AgNPs.

AgNO₃ Concentration

Chemical disinfection process with silver nitrate solution of the following concentrations: 0.5 mM to 2. To ensure that adequate silver ions were available for reduction, 5 mM was chosen and tried. By using UV-Vis spectroscopy the efficiency of nanoparticle synthesis at various concentrations of AgNO₃ was determined.

Temperature

At the same time, the influence of the reaction temperature on the synthesis process was investigated; it was increased from 22 to 42 degrees Celsius. UV-Vis measurements were performed at all the temperatures for stable formation of nanoparticles.





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Characterization of Silver Nanoparticles

Visual Inspection: The synthesis of AgNPs was first revealed by colour change of the reaction mixture to grey colour. The color change to a dark brown color meant that there was a decrease in silver ions and the development of AuNPs exploding the surface plasmon resonance (SPR). These visual patterns could be used as the first clue demonstrating that the nanoparticles had been successfully produced.

UV-Vis Spectroscopy

UV-Vis spectrophotometry analysis was performed to affirm formation of AgNPs and to study the optical behavior of the sample. Samples were analyzed in the UV-Visible region by scanning wavelength from 300–700nm and a peak at 430nm was obtained. This specific value is due to the SPR of silver nanoparticles and implies the formation and stability of the synthesized AgNPs.

FTIR Analysis

FTIR was conducted because it allows for identification of functional groups responsible for reduction and stabilization of the AgNPs. The authentication of *Menthapiperita* extract and AgNPs was performed and the spectrum of the two samples was super imposed to observe changes made after the preparation of nanoparticles. Some broad bands were captured at 3284cm⁻¹ that was due to O-H stretching along with the reduction of AgIons and 2120cm⁻¹ C=C=O stretching, 1637 cm⁻¹C=C stretching, 1476 cm⁻¹ C-H bending and 1272 cm⁻¹ C-O stretching indicated that all those functional groups existed in the extract (Islam, M. et al.,

Transmission Electron Microscopy (TEM)

The synthesized AgNPs were characterized by TEM which is useful in determination of the size and disaggregate morphology. The specimens were obtained by placing a drop of the nanoparticle solution on to a carbon coated copper grid, which was then allowed to air dry. The morphology characterization of the synthesized nanoparticles was done using TEM and the results depicted that it has a mostly spherical shape and the size of nanoparticles is in the range of 10–200 nm. The average particle diameter of the synthesized AgNPs was ~ 20 nm; Therefore, the information disrupted the structural characteristics of the synthesized AgNPs and as a consequence indicating that they are nano sized (Thuraisingamet al., 2010).

Energy Dispersive X-ray (EDX) Analysis

Energy-dispersive X-ray spectroscopy also known as EDX was administered in order to neutralize the concentration of elements and purity levels of the produced AgNPs. At this stage the obtained nanoparticles were characterized by the use of scanning electron microscope equipped with an EDX. Taking the spectrum analysis results into consideration now, here are some observations: While analyzing the spectrum of the solution, a high intensity of silver was recorded at 3 keV, followed by a very low intensity of other elements, so it means that silver nanoparticles have been synthesized on the solution without much of the other elemental interference.

Incorporation of AgNPs with Chicken Collagen Collagen Extraction and Encapsulation

The process of Collagen extraction, and encapsulation of silver nanoparticles (AgNPs) were pivotal in expanding the functional characteristics of the developed nanoparticles, especially with regard to dispersion stability and bioavailability. Triturated skin of chicken was used to isolate collagen for this study which was preferred due to its high collagen content and ease of extraction. To start the process, the chicken skins were first washed and deboned then trimmed of excess fat and ensure all were free from any other unwanted substances. The sex separated cleaned skin was then treated to an acid digestion process using acetic acid which was used to solubilize the collagen fibers. After the acid digestion, the collagen solution was purified for non-collagenous proteins and other materials which was followed by precipitation. The process of purification included dialysis of the collagen solution against distilled water; this helped in the removal of smaller molecules inclusive of residual acids thus concentrating the collagen solution. The resulting collagen was lyophilized to get it in a powder from which the collagen was confirmed to be pure and of the correct structure by UV-VIS and FTIR studies. The percentages of collagen



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incorporation and the efficiency of fibroblast adhesion of the scaffold were investigated using UV-Vis spectroscopy, and characteristic absorption maxima were obtained. Characterization of the functional groups in collagen and the confirmation that there is no appreciable degradation or contamination were done using FTIR analysis (Li *et al.*, 2007). In the preparation of the AgNPs with the extracted collagen, the idea was to improve the functional properties of the nanoparticles by coating the AgNPs with collagen to make it better compatible with biological systems. In conjugating the synthesized AgNPs with collagen, the AgNPs dispersion was mixed with a collagen solution under controlled conditions to effect coating of the particles with the protein. The prepared suspension was stirred slowly in order to enhance the nanoparticles/collagen molecules interaction which will enhance the encapsulation process (Calinet *et al.*, 2010).

Antimicrobial activity and Wound Healing Assays

To determine the curative effects of the collagen-encapsulated AgNPs, the antimicrobial and in vitro wound healing activities were assayed. These assays were supposed to determine the effectiveness of the nanoparticles to reduce the formation of biofilm and to stimulate the process of healing in the cells.

Antimicrobial Activity

The attempts for the use of collagen-encapsulated AgNPs were made to determine the yields in terms of its antimicrobial activity against various species of bacterial pathogens such as *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa* using the standard disc diffusion techniques. Disc diffusion methods incorporated using autoclaved discs with collagen encapsulated-nanoparticles that were then applied gently on nutrient agar plates seeded with the target bacteria. The bacterial plates were then incubated under the best condition for the bacterial growth and the measuring of the zones of inhibition around the discs was done after the specific time of incubation was over. The size of the inhibition zones allowed for a more comparative evaluation of the nano-template's antimicrobial properties with bigger zones suggesting greater effectiveness.

In vitro wound healing assays

The wound healing ability of the nanoparticles was further assessed by wound healing assays which are in vitro models that try to mimic the wound healing process. These assays were cytotoxicity assay and the wound healing migration assay which were done on Vero cells, a type of cell line generally used for in vitro wound healing assays.

Cytotoxicity Assay

Cytotoxicity assay was then performed to determine the biocompatibility of the collagen-coated AgNPs on Vero cells to know their toxic impact on cell survival. Cell signaling studies were performed treating cells with 0, 10, and 100 µg/mL of the nanoparticles. This assay and determined the overall metabolic activity of cells thereby giving an estimation of the viable cells present. Altogether, the findings suggested that the particles were relatively harmless at the disclosed concentrations and exerts negligible influence on the cell death rate (Badylak, *et al.*, 2002).

Scratch Assay

Scratch assay was carried out to assess the cell migration ability, an important factor of wound healing with the help of nanoparticles. Wound healing was performed with Vero cells growing in a monolayer: a scratch was made in the monolayer, and the cells' migration into the scratch was observed with time while in the presence of collagen-encapsulated AgNPs. Cell migration and the rate at which the scratch was closed was determined and higher rates of closing was an indication of better wound healing properties. The studies proved that the nanoparticles enhanced the migration of cells tremendously and thereby have a potential to enhance the process of healing (Badylak *et al.*, 2002).



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RESULTS AND DISCUSSION

Synthesis and Characterization of AgNPs

Collection of Medicinal Plant Materials

Six different plant species were used in the study from particular site of Chennai. The collected plants are mint (*Menthapiperita* L.), manthari (*Bauhinia purpurea* L.), white chaste tree (*Vitexleucoxydon* L.), mehandhi (*Lawsoniainermis* L.), hibiscus (*Hibiscus rosa-sinensis* L.), and Indian mint (*Saturejadouglasii*). The plants were selected depending on the favorable environmental factors, health of the plants etc. Reliability of the said materials is paramount for replication of these results because, collection sites influence the phytochemical profile of the plant species used in the synthesis of nanoparticles.

Extraction of Phytochemicals from Plant Materials

Six different plant species were used in the study and phytochemical extracts were extracted by using water based processes (Figure 1). The extraction process proved helpful in the isolation of the bioactive compounds required in the restoration of silver compounds by transforming Ag^+ into Ag^0 . Concerning the color and clarity of the extracts obtained from the various plants, they differed, thus pointing to the different phytochemicals extracted and required for the green synthesis of AgNPs (Gurtner *et al.*, 2008). This method of extraction ensures the retention of active components which are very vital in the formation of nano particles going with other authors who found that water based extraction is very useful in getting potent reducing agents (Richmond *et al.*, 2013).

Synthesis of Silver Nanoparticles (AgNPs)

Particularly, the synthesis of AgNPs was carried out by boro-hydride reduction method. The color change to brown in the solution was highly enhanced from *Menthapiperita* L. extract indicating a higher concentration of the extract and effectiveness in the reduction of silver ions. This colour change is explained by the formation of nanoparticles, by surface plasmon resonance (SPR) phenomenon present in metallic nanoparticles (Rodero and Khosrotehrani, 2010). The incorporation of a capping agent was effective in the prevention of nanoparticle aggregation and maintaining nanoparticles stability in the solution which concurs with other publications that describe green synthesis approaches of plant mediated methods in nanoparticle synthesis where the role of plant extracts play the function of stabilizing agents (Choi & Webster, 2012).

Optimization of Various Parameters for Silver Nanoparticle Synthesis

Concentration of Plant Extracts

Accordingly, the amount of *Menthapiperita* extract which was most effective was the one in the concentration of 2.5% in a 1mM $AgNO_3$ solution for the preparation of the CSP. From UV-visible spectrophotometric study, it was observed that at this concentration, there was a maximum absorbance at 430 nm as shown in Figure 2. This peak shows that AgNPs formed effectively, since the high concentration of plant extract avail the large number of reducing agents that hasten the formation process. The concentration of 2.5% contributed to the almost ideal reaction environment which further corroborates with the mentioned research findings that increased concentrations help in increasing the reduction efficiency of plant mediated nanoparticle synthesis.

pH

This study reveals that the optimum pH for the synthesis of AgNPs was pH 8. From the UV-visible spectrophotometric data, it was determined that pH8 depicted the highest absorbance peak and hence the best conditions for the synthesis of nanoparticles in this case (Figure 3). Stabilizing the pH at 8 proved to affect the charge and stability of the nanoparticles and thus promoted their formation and growth because literature shows that the pH level dramatically affects the synthesis and stabilization of nanoparticles (Choi & Webster, 2012).





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Concentration of AgNO₃

From the above investigation, the highest production of AgNPs was achieved at a concentration of 2 mM with regards to AgNO₃. Concentration of 5 mM, confirmed from the UV-visible spectrophotometric analysis shown in figure 4. This concentration gave the maximal absorbance peak which confirm or shows that the Ag ions are readily available for reduction. Patterns of optimum concentration reveal that higher values result into generation of more nanoparticles; however, high concentration is limited due to aggregation since high ionic solution may result to unplanned growth of the particles (Bera&Basak, 2014).

Temperature

From the above findings it can be concluded that the temperature at which the synthesis of AgNPs was most optimum was 42°C. This was, again in support with the UV-visible spectrophotometric analysis, where the peak absorbance was recorded at this temperature, which is the optimum temperature for the development of nanoparticles (Figure 5). This temperature increase helps in the faster reduction and synthesis hence faster formation of the nanoparticles and perhaps the formation of even smaller nanoparticles because of faster nucleation probably as a result of temperature optimization in studies of nanoparticles (Li et al., 2007).

Stability Analysis

The prepared AgNPs using *Menthapiperita* were stable from 1hr to 90 days and its UV-Vis showed the peak at 435 nm as depicted in the Figure 6. As time went on, the peak becomes clearer, which suggests that the nanoparticles are progressively becoming more stable. Changes were detected at 435 nm in 6 hours, while the steady peaks at 450 nm were put in 24 hours and 3 months. This stability imply a constant size and shape of the synthesized nanoparticles over a period of time which is important when being used in biomedical fields (Frykberg& Banks, 2015).

Characterization of Green Synthesized Silver Nanoparticles

Visual Inspection

The formation of *Menthapiperita* extract mediated AgNPs was further corroborated biinally by the change in color from light yellow to dark brown color. This change is characteristic of nanoparticles' formation because of the surface plasmon resonance (SPR) phenomenon, which regards the interaction of a material or an object with light of certain wavelength corresponding to its size and geometry. The detected change in color complies with general features of metallic nanoparticles' appearance after synthesis, indicating the process's completion. This visual confirmation of synthesized AgNP is in tune with literature reports where the color change of the solution is reported during the green synthesis of silver nanoparticles employing plant extracts (. Ullah and Bussmann, 2017). This colour change due to SPR is typical of metallic nanoparticles and helps in arguing the presence of silver at the nanoscale (Ullah & Bussmann, 2017). This testifying change produced by *Menthapiperita* supports its role of a reducing and stabilizing agent characteristic in the synthesis of nanoparticles that were disclosed in other research works where plant extracts were used in green synthesis.

UV-Vis Spectroscopy

The UV-Vis spectra of the biosynthesized AgNPs presented a shoulder band in range of 340-450 nm, the higher maximum absorbance value at 430 nm for *Menthapiperita* L extracts (Figure 7). These values of absorbance are characteristic to silver nanoparticles and represent the surface plasmon resonance and therefore the synthesis and stabilization of the nanoparticles are successful. This particular range of absorbance matches what has being found from other related research on AgNPs that has been synthesized using various biological techniques. Therefore, the extent of size reduction and stabilization of nanoparticles as proxied by the UV-Vis spectra corroborates the efficiency of *Menthapiperita* extract for the green synthesis of AgNPs as portrayed in the literature on optical characteristics of silver nanoparticles synthesized using extracts of plants (Herskovitz et al., 2016).

FTIR Analysis

The *Menthapiperita* extract was evacuated to generate FTIR spectra as follows: The extract gave peaks at 3284 cm⁻¹, 2120 cm⁻¹, 1637 cm⁻¹, 1476 cm⁻¹, and 1272 cm⁻¹; which belongs to O-H, C=C=O, and C- H bend functional groups





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respectively See (Figure 8). These groups are of importance in reducing the silver ions and in stabilizing the formed nanoparticles; herein, information on the chemical processes during green synthesis is revealed. These peaks can be explained as bonds and stretches characteristic for organic molecules within the precipitate interacting with Ag⁺ during nanoparticle formation. These interactions help in the reduction of Ag⁺ to Ag⁰ and significantly aids in stabilizing the nanoparticles by avoiding their agglomeration which is in accordance with the other works reported on the green synthesis involving plant extract. These functional groups give support to the part played by phytochemicals in the extract as efficient reagents in the synthesis process (Rodero&Khosrotehrani, 2010).

Transmission Electron Microscopy (TEM)

As observed from the TEM images, *Menthapiperita* based synthesized AgNPs were predominantly spherical in shape having size between 10-200 nm (Figure 9). It was also observed that the nanostructures' morphology and size increase as the concentration of the plant extract increases. Nano-size and shape of the nanoparticles determining the properties like optical properties as well as the antibacterial properties. Which makes sense when compared to prior research on plant-based synthesis, which shows that the morphology of the resulting nanoparticles actually depends on the concentration of the extract and the chemical content of the reducing agents thereof (Choi & Webster, 2012). This variability has shown that plant extracts are very effective when used in green synthesis methods.

Energy Dispersive X-ray (EDX) Analysis

Figure 10 demonstrates the EDX spectrum of the synthesized AgNPs wherein the presence of Ag-element with maximum peak at 3 keV and no other peak other than the silver element noticed that confirmed the birth and purity of the Silver nanoparticles. No peaks of other elements present demonstrated low level of impurities, which corroborated with the quality of synthesized nanoparticles. The low level of the presence of other elements demonstrates that the green synthesis process for the formation of AgNPs was successful in yielding samples with high purity and without the interference of impurities from the plant extract or the synthesis milieu. This finding is in concurrence with other works which have revealed similar purity of silver nanoparticles synthesized using plant extracts, which clearly substantiates the green synthesis technique as a means of procuring nanoparticles of acceptable quality (Ullah&Bussmann, 2017).

Antimicrobial Analysis of Silver Nanoparticles:

Menthapiperita derived AgNPs resulted the zone of inhibition against both the Gram positive and negative bacterial pathogens. These zones of inhibitions were determined to be 22 mm for *Bacillus subtilis*, 20 mm for *Staphylococcus aureus*, 22 mm for *Pseudomonas aeruginosa* and 20mm for *Escherichia coli* (Figure 11). These findings are quite similar to the reference antibiotic Gentamicin as evident by the high antibacterial efficacy of synthesized AgNPs. The ability to eradicate over ninety percent of bacteria strengthens the aspect of AgNPs as a replacement to the already fading antibiotics effective against antibiotic resistant bacteria. The large inhibition halos measured for *Menthapiperita* derived AgNPs against *Bacillus subtilis* (22 mm), *Staphylococcus aureus* (20 mm), *Pseudomonas aeruginosa* (22 mm), *Escherichia coli* (20 mm) showed the effectiveness of synthesized AgNPs. It is for this reason that nanoparticles are effective in their nanoscale distribution and size, which enhances their interaction with bacterial cell membranes. The antibacterial activity is mainly concern with the ions released from the nano-silver, which be taken into bacterial cell to interrupt metabolic process and induce oxidative stress and then lead to cell death (Frykberg& Banks, 2015).The active mechanism of antibacterial activity of nano-silver is associated with the reaction of silver ions with SH groups in bacterial proteins and DNA interfering with vital cell functions. It leads to alteration in the structural and membrane characteristic of the bacterial cell, increased permeability, and release of enzyme that degrades the bacterial cell wall and hence killing of the bacteria. Besides the mentioned impacts, it is reported that AgNPs induce the generation of ROS which in general boost them up their antibacterial aptitudes via inducing oxidative damage to the lipids, proteins, and DNA of the bacterial cell (Rai et al., 2012). Further, the zones of inhibition evident against both the Gram-positive and the Gram-negative bacteria suggest that AgNPs have a broad spectrum activity that is desirable when developing drugs used in the management of infections produced by different bacterial genera. *P. aeruginosa* and *E. coli* are producers of biofilms and were shown to have an additional outer membrane which can be argued to have been overcome by the AgNPs considering that they are hard targets to the conventional antibiotics.



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The reported broad-spectrum activity makes AgNPs to be very useful in combating MDR bacterial strains, which are some of the main challenges facing contemporary healthcare systems (Ahamed *et al.*, 2010). The findings are in support with other works that have recorded similar antibacterial effectiveness of silver nanoparticles that are prepared from plant extracts. For instance, Gurunathan *et al.* (2014) worked on AgNPs fabricated by using *Azadirachta indica* and realized that the synthesized compound was as effective as the antibiotics as it formed equal zones of inhibition against several bacteria. This supports the prospect on plant synthesized AgNPs in combating bacteria through the research proposal by Gurunathan *et al.*, (2014).

In Vitro Cytotoxicity Assay

In terms of cytotoxicity, Assay with Vero cells involves determination of cell viability with AgNPs that present cell viability between 89%, 93%, 97%, 98% at chosen concentrations of 20 µg/mL, 50µg/mL 75 µg/mL, 100 µg/mL respectively. From these results it is clear that at the given concentration of the biomolecules the synthesized AgNPs are biocompatible and therefore may be used for biomedical applications including; wound healing and drug delivery. This has an implication, in the context of their therapeutic application, with regard to the little or no harm which they are likely to inflict on normal cells (Badylak *et al.*, 2002). The high percentage of live cells indicated means that regardless of the cell type, silver nanoparticles indeed possess a high degree of biocompatibility which may further support for other applications in the biomedical fields. The maintained balance of the viability rates centrally that AgNPs do not lead to the disturbance of the vital processes under concentrations that may be useful for the medicinal purposes and owed to such, their effectiveness in wound healing and as drug delivery systems (Choi & Hu, 2008). Similar to Foldbjerget *et al.*, they affirm on the biocompatibility argument by showing that even at rather high concentrations, AgNPs has negligible impact on cytotoxicity of mammalian cells. This confirms the possibilities of safe use of AgNPs in biomedical applications for instance in drug delivery and tissue engineering since cell viability is very important (Foldbjerget *et al.*, 2009) (Figure 12 & Table 1).

Apoptotic Activity

AgNPs caused apoptosis in Vero cells by binding to DNA and showing green fluorescence with acridine orange and red fluorescence with propidium iodide for chromatin feature and apoptosis respectively as shown in Figure 13. Higher activation of caspase-3/9 supported the findings indicative of apoptosis induced by the AgNPs. This indicates that it can be useful in cancer treatment as well as in the process of healing of a body's wound because there is need to cause death of impaired of cancerous cells (Li *et al.*, 2007). Foldbjerg *et al.* (2011) have demonstrated that silver nanoparticles cause apoptosis in cancer cells through oxidative stress and the intrinsic pathway. This work established that there is a direct relationship between effects of AgNPs and ROS levels such that since ROS causes DNA damage the next effect is activation of apoptotic pathways such as caspase cascade. This correlates with the discover that AgNPs can cause apoptosis in Vero cells, possibly by the same pathways (Foldbjerget *et al.*, 2011). Gurunathan *et al.*, (2015) concluded that silver nanoparticles have the ability to kill leukemia cells through apoptosis by the generation of reactive oxygen species and activation of the intrinsic pro-apoptotic pathway. The study noted elevated caspase-3 levels, and condensed chromatin pattern, typical of apoptosis as seen in the present research (Gurunathan *et al.*, 2015).

In-vitro scratch wound healing assay

Utilizing scratch assay, we looked at how well AgNPs plant extract healed wounds. To find out which chemicals have wound-healing properties, this is a common and easy way to do so. Fibroblasts & keratinocytes migrate and proliferate during this stage of wound healing, and they're connected. This test reproduces conditions under which cells migrate in body after wound heals. Figure 14 and Table 2 show that tested AgNPs were able to seal scratched gap more quickly.





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CONCLUSION

The present investigation was able to synthesize successfully AgNPs using *Menthapiperita* extract and also encapsulated them with chicken collagen which showed enhanced antimicrobial activity and wound healing ability. Hence the encapsulation with collagen enhanced the solubility, stability and enhanced biocompatibility of the AgNPs leading to cell proliferation and migration without any toxic effects which enhanced the use of *Menthapiperita* in modern medicine. These studies reveal that collagen-encapsulated AgNPs can be used as effective wound healing agents that can improve the aspects of treatments now available on the market by combining the effects of natural extracts and nanotechnology. Thus, for the next steps of research, it is necessary to conduct experimental and clinical studies in vivo to confirm these initial findings and to investigate the possibility of the use of these nanoparticles in clinical practice, as well as to research specific guidelines on the application of these nanoparticles in the wound healing products. The findings of this study reveal a new way to fuse conventional comprehensive medicinal practice with modern nanotechnology, which provides a viable course for inventing adequate opportunities for wound management with the utilization of therapeutic silver nanoparticles during the healing process of the skin.

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Table 1: Table showing the cell viability test result

Concentrations (µg/mL)	Absorbance		Average	Cell viability (%)
	I	II		
Control	0.887	0.893	0.89	100
20	0.877	0.879	0.878	98.65168539
40	0.863	0.866	0.8645	97.13483146
60	0.852	0.847	0.8495	95.4494382
80	0.84	0.833	0.8365	93.98876404
100	0.799	0.8	0.7995	89.83146067

Table 2: Table showing the *in-vitro* scratch wound healing activities of AgNPs

S. No.	AgNPs		Control	
	Time (hr)	Healing (%)	Time (hr)	Healing (%)
1	0	0	0	0
2	24	30.41	24	27.91
3	48	49.58	48	43.33
4	72	63.33	72	58.33

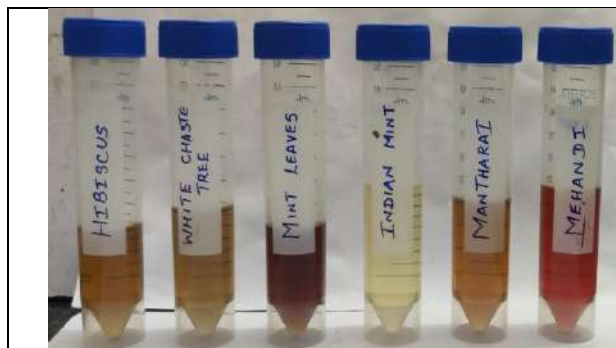


Fig-1: Image depicting phytochemical extracts from different plants

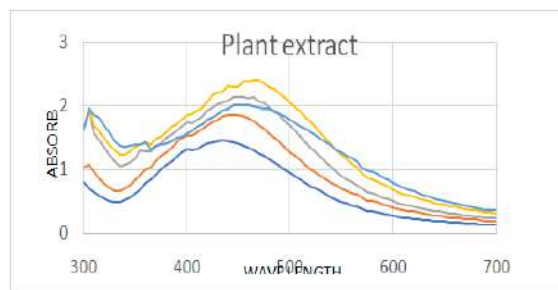


Fig-2: Photograph displaying UV-Vis peaks of various concentrations of plant extracts





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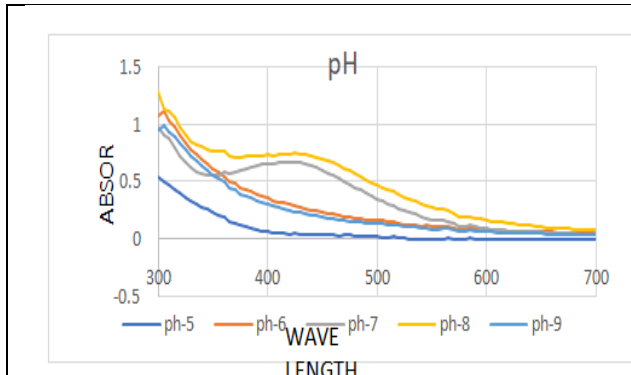


Fig-3: Image displaying UV-Vis peaks of extracts examined at various pH levels

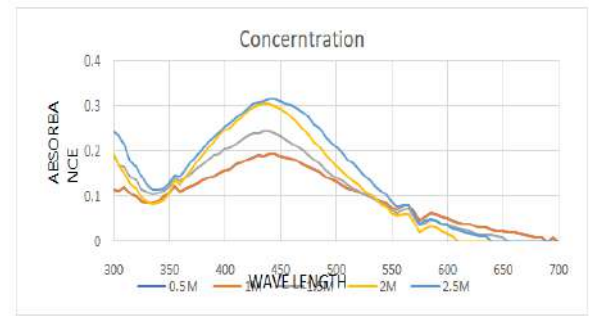


Fig-4: Pictorial representation of extract's UV-Vis peaks as a function of AgNo3 concentration

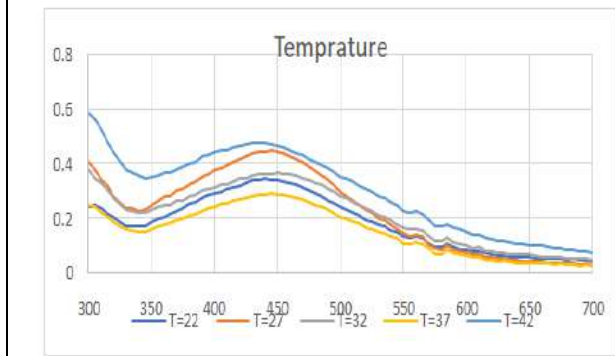


Fig-5: Photo displaying extract's UV-Vis peaks at various temperatures

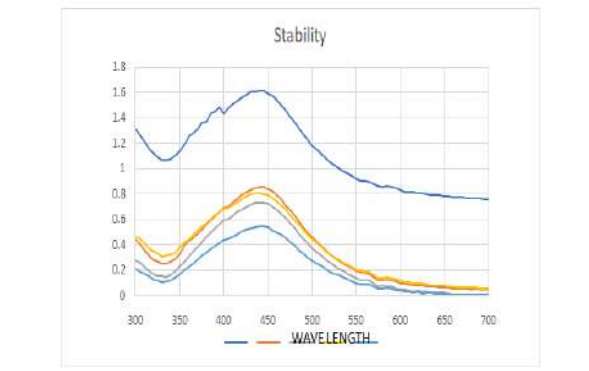


Fig-6: Image displaying extract's stability-testing UV-Vis peaks

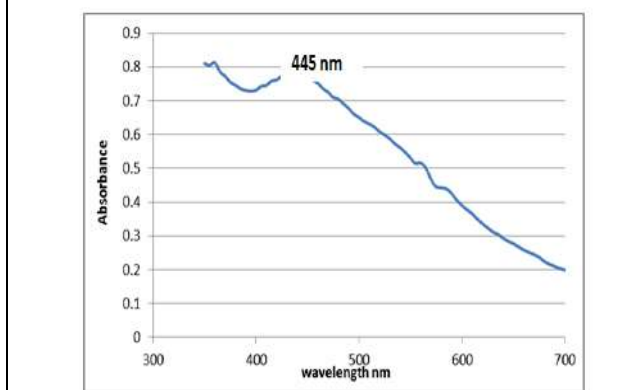


Fig-7: Photograph showing the UV-Vis peaks of the *Menthapiperita L.* extract

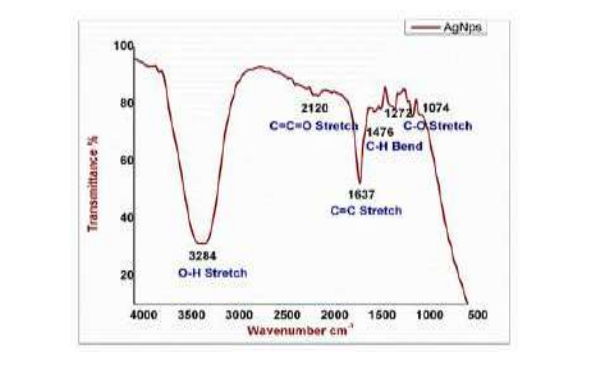


Fig-8: FTIR analysis of silver nanoparticles produced by *Menthapiperita L.*





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<p>Fig-9: TEM images of the prepared AgNPs at three different sizes (20 nm, 50 nm, and 10 nm)</p>	<p>Fig-10: Energy dispersive X-ray (EDAX) spectrum of AgNPs</p>
<p>Fig-11: Antibacterial activity of synthesized silver nanoparticles (SN – Silver Nanoparticles & PC – Positive Control (Gentamicin))</p>	<p>Fig-12: Images of cytotoxic capability of AgNPs at different concentrations</p>
<p>Fig-13: Photos displaying apoptotic processes of AgNPs using various dyes</p>	<p>Fig-14: Photographs of in-vitro scratch wound healing activities of AgNPs</p>





Qualitative and Quantitative Analysis of “Vellai Kungiliyam” In Various Purification Methods

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ABSTRACT

The Siddha system of medicine mainly emphasizes health as the perfect state of a person's physical, psychological, social, & spiritual well-being. One of the significant aspects of the Siddha system is the purification of raw drugs before using them to make medicines. The term *Suddhi* means to get rid of impurities. The *Vateria indica* is a tropical tree that is endemic to the Western Ghats of India & belongs to the family Dipterocarpaceae. The dammar resin obtained from the bark of the tree is used in wounds, leucorrhoea, swelling, cough, asthma, leprosy, & skin eruptions. *Vateria indica* resin regulates the *Tridosha* (*Vatham*, *pitham*, *kapham*) of the body. *Vellai Kungiliyam* is purified using a variety of purification methods, & the phytochemical analysis of separate three samples were evaluated. *Vellai Kungiliyam* is purified as per Siddha literature using three different methods. Physiochemical characterization such as loss on drying, ash values, extractive values, qualitative phytochemical screening, & TLC/HPTLC analysis were estimated as per Pharmacopoeia Laboratory for Indian Medicines (PLIM) guidelines. HPTLC fingerprinting of Sample I revealed the presence of five prominent peaks & the R_f value ranges from 0.02 to 0.90 whereas sample III showed the presence of seven prominent peaks & the R_f value ranges from 0.00 to 0.83. The present study revealed that the bioactive compounds were present in large amounts in purification by *Thiriphala kudineer* (Sample II). The phytochemical analysis confirms the presence of Alkaloids, Carbohydrates, Saponins, Phenols, Tannins, Flavonoids, & Diterpenes. The *Vellai*





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kungiliyam purified with *Thiriphala kudineer* is known to have the highest therapeutic value in comparison to the other two samples.

Keywords: HPTLC, Physio-chemical analysis, Purification, *Vateria indica*.

INTRODUCTION

Nowadays, Herbal medicines are becoming a widely popular form of health care & it has witnessed a renaissance among consumers throughout the world. One of the oldest systems of medicine in the world that treats the body as well as the mind & the soul is Siddha medicine. The Tamil term *siddhi* means a goal to be achieved, perfection, or heavenly bliss [1]. The recent upsurge of interest in the Siddha system can be seen in the large-scale manufacture of Siddha formulations. However, one of the impediments to the acceptance of the ancient systems of medical preparation is the lack of standard quality control profiles. The process of prescribing a set of standards or intrinsic qualities, constant parameters, & unambiguous qualitative & quantitative values that convey an assurance of quality, efficacy, safety, & repeatability is known as the standardization of herbal medicines.

Suddhi (Purification) of the raw drug is a process aimed at removing the impurities & toxic substances to some extent or potentiating their chemical transformation into nontoxic or comparatively less toxic chemicals, improving the potency, & efficacy, enhancing the synergistic effect of the drug [2]. No medicinal preparation can be done without prior *Suddhi muraigal* (Purification process). The three main phases in herb purification are drying, grinding, & sieving. The secondary purification process entails concentration, drying, & extraction using the appropriate solvents. Extensive separation & purification processes such as solvent-solvent extraction, solid-phase extraction, & liquid chromatography are needed for further purification to produce pure phytochemicals. In addition, thin-layer chromatography (TLC), high-performance liquid chromatography (HPLC), paper chromatography (PC), & gas chromatography (GC) were used in the separation & purification of the secondary metabolites[3].

According to the Indian system of medicine *Vateria indica* L. is used as a tonic, carminative, & expectorant. It is an important medicinal plant that is endemic to the western ghats of India & comes under the family *Dipterocarpaceae*. The resin obtained from this plant has the same uses as pine resin. Phytochemical analysis of *Vateria indica* L. stems revealed the occurrence of carbohydrates, tannins, phenols, & flavonoids in the aqueous & ethanolic extracts. The leaves & roots also have the presence of bergenin, hopeaphenol, stilbenoids, bergenin and benzophenone. The trees of the *dipterocarpaceae* family are primarily found in evergreen & semi-evergreen forests, near the streams of southern Western Ghats. *Vateria indica* was first described by Hook & Gamble in 1874 & 1915. Since then, many researchers have documented it from different sites in the southern western ghats of India, namely Kerala, Karnataka, & Tamilnadu. Traditional medicine & astrology also provide references that help us comprehend their ties to the national culture & heritage. Resins are usually mixtures of organic substances. Plants produce resins in response to injury because of their defensive properties. Resin is one type of secondary metabolite, that shields the plant from infections & insects.

In Siddha medicine, a resin called *vellai kungiliyam*, which is obtained from *Vateria indica* trees, has therapeutic properties. *Vellai kungiliyam* is a component of medicinal oils that are used to cure Vadha illnesses. It works better for disorders caused by *Vatham*. Resin is produced through the reaction of volatile oil & oxygen. They are primarily composed of hydrocarbons. Resins cannot be dissolved in water. They are soluble in both alcohol & ether. The ancient Egyptians coated food storage containers with resin to prevent food from rotting. Some resins are produced in the roots. Many of the resins come from families including *Dipterocarpaceae*, *Anacardiaceae*, *Burseraceae*, *Guttiferae*, *Fabaceae*, *Mimosaceae*, *Stryraceae*, *Umbelliferae*, *Liliaceae*, *Pinaceae*, etc.





Resins are generally categorized into three groups. They consist of hard resins, Oleo resins &, Gum resins. The hard resins are further divided into three categories. The three are lacquer, shellac, & damars. The word ' damar ' is a Malay word. It refers to burning material. 'Damars' refers to *kungiliyam* varieties in trade. The resin is obtained by scratching in the bark & phloem, after which it is obtained & collected. It appears to be white-colored fragments of marble [4]. *The Vellai kungiliyam* has a variety of pharmacological effects, including anticancer, antitumor, anti-inflammatory, & antiulcer properties [5-6].

As per Siddha system *Vellai kungiliyam* is purified by different methods, qualitative & quantitative analysis were done as per PLIM guidelines. Therefore, the purpose of the study is to purify the *Vellai kungiliyam* in three different methods & analyze the chemical changes that occurred during the purification process of *vellai kungiliyam* scientifically [7-8].

MATERIALS AND METHODS

Procurement of the raw drugs

The required drugs for the purification of *Vellai kungiliyam* were procured from a well-reputed country raw drug shop in Parris Corner, Chennai. All the ingredients were purified in the *Gunapadam* laboratory at the National Institute of Siddha.

Identification & Authentication of the drug

The collected raw materials were identified & authenticated by the Assistant Professor, Department of Medicinal Botany, National Institute of Siddha, Tambaram Sanatorium.

Purification of *Vellai kungiliyam* - Process 1 (Sample 1)

Required ingredients

1. *Vateria indica* L. (*Vellai kungiliyam*)
2. *Citrus lemon* (*Elumichai*)

Method of Purification

The *Vellai kungiliyam* was soaked in lemon juice & dried.

Purification of *Vellai kungiliyam* : Process 2

Required ingredients

1. *Terminalia chebula* (*Kadukkai*)
2. *Phyllanthus emblica* (*Nellikai*)
3. *Terminalia bellerica* (*thantrikkai*)

Method of Purification

The *Vellai kungiliyam* was packed in a cloth, soaked in *thiriphala kudineer* & then dried.

Purification of *Vellai kungiliyam* - Process 3 (Sample 3)

Required ingredients

1. Bark of *Azadirachta indica* (*Vembu pattai*)
2. Root of *Solanum Xanthocarpum* (*Kandankathiri ver*)
3. *Trichosanthes cucumerina* (*Peipudal*)
4. Leaf of *Justicia adathoda* (*Adathodai*)

Method of Purification

Veppampattai, *Kandankathiri ver*, *Peipudal*, *Adathodai ilai* each measuring 35 grams is added with 2 liters of water & boiled for a few hours till the water is reduced to 1/8th ratio. Then a cloth is tied up on the mouth of the vessel containing *Vellai kungiliyam* & is closed by the lid & ignited for a few hours till the *Vellai kungiliyam* reaches wax consistency. Following that *Vellai kungiliyam* is washed in water & dried.



**Kiruba Annammal et al.,****Storage**

The purified *Vellai kungiliyam* was stored in a clean, dry, air-tight container & then it was sent to the laboratory for analysis.

Qualitative & Quantitative analysis were carried out as per PLIM guidelines**Organoleptic properties**

This provides first-step information regarding the identity, purity, & quality of the drug.

The organoleptic characters of the samples were evaluated which include their state, nature, odour, touch, flow property, & appearance. The results are shown in Table 1.

Physicochemical analysis

Physico-chemical studies of the plant drugs are necessary for standardization, as it helps in understanding the significance of physical & chemical properties of the substance being analysed in terms of their observed activities & especially for the determination of their purity & quality. The analysis includes the determination of Total ash, Loss on drying at 105°C, acid-insoluble ash, water-soluble extractive, & alcohol-soluble extractive, which were carried out as per the procedures mentioned in standard references. Based on the AYUSH PLIM Guidelines, results are presented in Table 2.

The solubility profiles using various solvents were executed on different samples of *Vellai kungiliyam* & its results are depicted in Table 3.

The following analytical parameters were studied for *Vellai kungiliyam* which is purified by different methods:

Percentage loss on drying

The test drug was accurately weighed in an evaporating dish. The sample was dried at 105°C for 5 hours & then weighed [9].

Determination of total ash

The test drug was accurately weighed in a silica dish & incinerated in the furnace at a temperature of 4000 °C until it turned white in color which indicates the absence of carbon. The percentage of total ash was calculated with reference to the weight of the air-dried drug.

Determination of acid insoluble ash

The ash obtained by total ash test was boiled with 25 ml of dilute hydrochloric acid for 6mins. Then the insoluble matter is collected in a crucible & washed with hot water & ignited to constant weight. The percentage of acid-insoluble ash was calculated with reference to the weight of air-dried ash.

Determination of alcohol soluble extractive

The test sample was macerated with 100 ml of alcohol in a closed flask for twenty-four hours, shaking frequently for six hours, & allowed to stand for eighteen hours. Filter rapidly, taking precautions against loss of solvent, evaporate 25 ml of the filtrate to dryness in a tared flat-bottomed shallow dish, & dry at 105°C, to constant weight & weigh. Calculate the percentage of alcohol-soluble extractive with reference to the air-dried drug.

Determination of water-soluble extractive

The test sample was macerated with 100 ml of chloroform water in a closed flask for twenty- four hours, shaking frequently for six hours, & allowed to stand for eighteen hours. Filter rapidly, taking precautions against loss of solvent, evaporate 25 ml of the filtrate to dryness in a tared flat-bottomed shallow dish, & dry at 105°C, to constant weight & weigh. Calculate the percentage of water-soluble extractive with reference to the air-dried drug [10].

Biological & Pesticide Residue Screening

Sterility Test by Pour Plate Method



**Kiruba Annammal et al.,****Objective**

The pour plate techniques were adopted to determine the sterility of the product. Contaminated /unsterile sample (formulation) when coming in contact with the nutrition-rich medium it promotes the growth of the organism & after the stipulated period of incubation the growth of the organism was identified by a characteristic pattern of colonies. The colonies are referred to as colony-forming units (Cfus).

Methodology

The test sample was inoculated in a sterile petri dish to which about 15 ml of molten agar 45°C was added. Agar & sample were mixed thoroughly by tilting & swirling the dish. Agar was allowed to completely gel without disturbing it. (about 10 minutes). Plates were then inverted & incubated at 37° C for 24-48 hours & further extended for 72 hrs for fungal growth observation. Grown colonies of organisms were then counted & calculated for cfu.

Qualitative phytochemical analysis

Phytochemical screening of the plant gives a vast idea about the chemical constituents present in the drug. Key metabolites of Alkaloids, Carbohydrates, Flavonoids, Glycosides, Phytosterols, Tannins, Phenols, Saponins, Diterpenes, gum, & mucilage, & Quinones were carried out as per the procedures quoted in the standard organic book. The results obtained on each test are given in Table 5. Figure 5-7 shows the qualitative phytochemical investigation of *Vellai kungiliyam* purified by different methods.

Detection of alkaloids

Extracts were dissolved individually in dilute Hydrochloric acid & filtered.

Mayer's Test: Filtrates were treated with Mayer's reagent (Potassium Mercuric Iodide). The formation of a yellow colour precipitate indicates the presence of alkaloids.

Dragendroff's Test: Filtrates were treated with Dragendroff's reagent (Potassium Bismuth Iodide). The formation of a red precipitate indicates the presence of alkaloids.

Wagner's Test: Filtrates were treated with Wagner's reagent (Iodine in Potassium Iodide). The formation of a brown/reddish precipitate indicates the presence of alkaloids.

Detection of carbohydrates

Extracts were dissolved individually in 5 ml distilled water & filtered. The filtrates were used to test for the presence of carbohydrates.

Molisch's Test: To 2 ml of plant sample extract, two drops of alcoholic solution of α - naphthol are added. The mixture is shaken well & a few drops of concentrated sulphuric acid are added slowly along the sides of the test tube. A violet ring indicates the presence of carbohydrates.

Benedict's Test: Filtrates were treated with Benedict's reagent & heated gently. Orange red precipitate indicates the presence of reducing sugars.

Detection of saponins**Foam Test**

0.5 gm of the extract was shaken with 2 ml of water. If the foam produced persists for ten minutes it indicates the presence of saponin

Detection of phenols Ferric Chloride Test

Extracts were treated with 3-4 drops of ferric chloride solution. The formation of bluish-black color indicates the presence of phenols.

Detection of tannins Gelatin Test

The extract is dissolved in 5 ml of distilled water & 2 ml of 1% solution of Gelatin containing 10% NaCl is added to it. White precipitate indicates the presence of phenolic compounds.



**Kiruba Annammal et al.,****Detection of Flavonoids**

Alkaline Reagent Test: Extracts were treated with a few drops of sodium hydroxide solution. The formation of an intense yellow colour, which becomes colorless with the addition of dilute acid, indicates the presence of flavonoids.

Lead acetate Test: Extracts were treated with a few drops of lead acetate solution. The formation of a yellow colour precipitate indicates the presence of flavonoids.

Detection of diterpenes Copper Acetate Test

Extracts were dissolved in water & treated with 3-4 drops of copper acetate solution. The formation of an emerald green color indicates the presence of diterpenes.

Test for Quinones

The extract was treated with sodium hydroxide blue or red precipitate indicating the presence of Quinones.

Test for Gum & Mucilage

To 1ml of extract add 2.5ml of absolute alcohol & stir constantly. Then the precipitate was dried in air & examined for its swelling properties. The swelling was observed which will indicate the presence of gum & mucilage.

TLC analysis

The test sample was subjected to thin layer chromatography (TLC) as per the conventional one- dimensional ascending method using silica gel 60f 254, 7x6 cm (Merck) was cut with ordinary household scissors. Plate markings were made with a soft pencil. Micro pipette was used to spot the sample for TLC applied sample volume 10-micro liter by using a pipette at 1 cm at 5 tracks. In the twin trough chamber with the specified solvent system after the run plates were dried & were observed using visible light short-wave UV light 254nm & light long-wave UV light 365 nm [11].

High-performance thin layer chromatography analysis

HPTLC method is a modern sophisticated & automated separation technique derived from TLC. Pre-coated HPTLC-graded plates & autosampler were used to achieve precision, sensitivity, & significant separation both qualitatively & quantitatively. High-performance thin layer chromatography (HPTLC) is a valuable quality assessment tool for the evaluation of botanical materials efficiently & cost-effectively. HPTLC method offers a high degree of selectivity, sensitivity, & rapidity combined with single-step sample preparation. thus, this method can be conveniently adopted for routine quality control analysis. It provides a chromatographic fingerprint of phytochemicals which is suitable for confirming the identity & purity of Phyto therapeutics.

Chromatogram development

It was carried out in camag twin trough chambers. Sample elution was carried out according to the adsorption capability of the component to be analyzed. After elution, plates were taken out of the chamber & dried.

Scanning

Plates were scanned under UV at 366nm. The data obtained from scanning were brought into integration through camag software. A chromatographic fingerprint was developed for the detection of phytoconstituents present in each sample & their respective rf values were tabulated [12].

RESULTS**Qualitative analysis**

Table 1 : Organoleptic evaluation of *Vellai kungiliyam* purified by 3 different methods

Table 2: Physico-chemical evaluation of *Vellai kungiliyam* purified by 3 different methods

Table3: Solubility profile of *Vellai kungiliyam* purified by 3 different methods

Table 4: Sterility test analysis of *Vellai kungiliyam* purified by 3 different methods by pour plate method

Table 5: Phytochemical Analysis for *Vellai kungiliyam* purified by 3 different methods





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DISCUSSION

Vateria indica L. is an evergreen medicinal tree that grows up to 30m in height indigenous to the evergreen forests of western ghats from north Karnataka to Kerala. It is used for the treatment of respiratory disorders like chronic bronchitis, throat troubles, tubercular glands, boils, piles, diarrhoea, & rheumatism. Studies have shown that the resin of *Vateria indica* is a complex mixture of several triterpenes, hydrocarbons, ketones, alcohols, & acids along with small amounts of sesquiterpenes. On distillation, oleoresin yields essential oils (76%) with a stray balsamic odour. Dipterocarpaceous plants (*Vateria indica* L.) belong to the family Dipterocarpaceae & are known to contain various resveratrol oligomers that exhibit a variety of biological activities such as antibacterial & antitumor effects. The organoleptic characters of *vellai kungiliyam* purified by three different methods are shown in Table no 1. All the samples were found to be solid in nature with non-free-flowing properties. Pharmaceutical powders may be classified as free-flowing or cohesive (non-free flowing). Frictional & cohesive forces (resistance to flow) are increased as the particle size is reduced.

In Physico-chemical parameters, the loss on drying test is to determine to measure the amount of water & volatile matter in a sample when the sample is dried under the specified conditions. Moisture is one of the major factors responsible for the deterioration of drugs & formulations. Thus, low moisture content could get maximum stability & better shelf life. The loss of drying at 105 °c was found to be 9.333 ± 0.210 % (sample I), 12.13±0.4453% (sample II), & 10.93±0.937% (sample III).

The Ash value is the residue remaining after incineration that determines the inorganic substances present in the sample. Similarly, it can also detect the nature of the material, whether it is adulterated or not. Hence, the determination of the ash value provides an idea for judging the identity & purity of the sample. The Ash values of *Vellai kungiliyam* were 0.3313± 0.03% (sample I), 0.5317±0.023 % (sample II), 0.64±0.039 % (sample III). Acid insoluble ash is the ash fraction that is insoluble in an acid & it is a measure of the index for siliceous impurities. The quality of the drug is better if the acid insoluble value is low. The Acid insoluble Ash values of *Vellai kungiliyam* were 0.017±0.003% (sample I), 0.03467±0.025% (sample II), 0.038±0.008% (sample III).

Extraction value determines the number of active constituents in each amount of the formulation when extracted with a solvent media such as water & alcohol. The water soluble & alcohol soluble extract values indicate the extent of polar & nonpolar compounds respectively. Usually, resins are insoluble in water but in these three samples, they show water-soluble extractive values. Both water & alcohol-soluble extractive value plays an important role in the evaluation of crude drugs. Water & alcohol-soluble extractive values of *Vellai kungiliyam* were 1.48± 0.216 %, 0.460±0.265 % (sample I), 2.373±0.308 %, 0.3272±0.188% (sample II), 3.51±0.476 %, 0.141±0.081 % (sample III) respectively. In the solubility test, all three samples were found to be soluble in ethanol. Increased ethyl alcohol extracts are suggestive of increased glycosides, flavonoids, & tannins. The ethyl alcohol extract of *Vateria indica* is found to be 1.014 % (w/w) as per previous studies . In the sterility test by pour plate method, there is no growth /colonies were observed in any of the plates inoculated with test samples I, II, & III.

In the phytochemical study of the Purified sample by Lemon juice, the bioactive compound present is alkaloids detected by Wagner's test. The purified sample by *Thriphala* decoction shows the presence of Alkaloids, Carbohydrates, Saponin, Phenols, Tannins, Flavonoids, & Diterpenes. The purified sample by the *pittaviyal* process shows the presence of Alkaloids detected by Wagner's test (Table 5). Table 7, summarizes the HPTLC analysis of *Vellai kungiliyam* purified by 3 different methods & Figure 8 shows the colour of spots visible in the TLC profiles of different samples of *vellai kungiliyam*. TLC & HPTLC are useful in the identification of individual compounds, & the clinical utility of *Vateria indica* resin & formulations based on this resin, especially in geriatrics & anti-tumor activities, can bring in newer horizons in the medicinal utility of this preparation & establish a firm phytochemical basis for its therapeutic properties. HPTLC analysis was performed & the study shed light on the active constituents present in *Vellai kungiliyam* which is depicted by the presence of 5 prominent peaks (sample I & II), 7 Prominent peaks (sample



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III) at 366nm & in which each peak corresponds to no of versatile components present within it. Sample I contain the Rf value of the peaks ranging from 0.02 to 0.90. Sample II contains the Rf value of the peaks ranging from 0.00 to 0.57. Sample III contains the Rf value of the peaks ranging from 0.00 to 0.83.

CONCLUSION

Vateria indica L. is purified using three different methods in this study. HPTLC fingerprinting analysis of purified sample III shows seven prominent peaks corresponding to the presence of five versatile phytochemicals present with it & it indicates that this purified sample will have higher efficacy in medicine preparations. *Vellai kungiliyam* purified by three different methods is soluble in ethanol, indicating the presence of glycosides, flavonoids, & tannins. The phytochemical screening provides additional evidence that sample II contains flavonoids, alkaloids, carbohydrates, saponins, phenols, & diterpenes. Therefore, it was concluded that samples II & III have the highest therapeutic value.

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Table 1 : Organoleptic evaluation of *Vellai kungiliyam* purified by 3 different methods

Organoleptic characters	Sample I	Sample II	Sample III
State	Solid	Solid	Solid
Nature	Slightly coarse	Fine powder	Coarse powder
Odour	Mild characteristic	Characteristic	Characteristic
Touch	Rough	Slightly coarse	Rough
Flow property	Non free flowing	Non free flowing	Non free flowing
Appearance	Pale whitish	Whitish	Pale whitish

Sample 1 – Purified *vellai kungiliyam* method I, Sample 2 - Purified *vellai kungiliyam* method II Sample 3- Purified *vellai kungiliyam* method III.

Table 2: Physico-chemical evaluation of *Vellai kungiliyam* purified by 3 different methods

S.no	Parameter	Sample I Mean (n=3) Sd	Sample II Mean (n=3) Sd	Sample III Mean (n=3) Sd
1.	Loss on drying at 105 °c	9.333 ± 0.210	12.13±0.4453	10.93±0.937
2.	Total ash (%)	0.3313±0.03	0.5317±0.023	0.64±0.039
3.	Acid insoluble ash (%)	0.017±0.003	0.03467±0.025	0.038±0.008
4.	Water soluble extractive (%)	1.48±0.216	2.373±0.308	3.51±0.476
5.	Alcohol soluble extractive (%)	0.460±0.265	0.3272±0.188	0.141±0.081

Table 3: Solubility profile of *Vellai kungiliyam* purified by 3 different methods

S.no	Solvent used	Sample I	Sample II	Sample III
1.	Chloroform	Insoluble	Insoluble	Insoluble
2.	Ethanol	Soluble	Soluble	Soluble
3.	Water	Insoluble	Insoluble	Insoluble
4.	Ethyl acetate	Insoluble	Insoluble	Insoluble
5.	DMSO	Insoluble	Insoluble	Insoluble

Table 4: Sterility test analysis of *Vellai kungiliyam* purified by 3 different methods by pour plate method

Sample	Test	Result	Specification
I, II, III	Total bacterial count	Absent	Nmt 10 ⁵ cfu/g
	Total fungal count	Absent	Nmt 10 ³ cfu/g





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Table 5: Phytochemical Analysis for Vellai kungiliyam purified by 3 different methods

S.no	Phyto chemicals	Test name	H ₂ O EXTRACT		
			Sample I	Sample II	Sample III
1.	Alkaloids	Mayer’s test	-ve	-ve	-ve
		Wagner’s test	+ve	+ve	+ve
		Dragendroff’s test	-ve	-ve	-ve
2	Carbohydrates	Molisch’ test	-ve	+ve	-ve
		Benedict’s test	-ve	+ve(mild)	-ve
3	Saponins	Foam test	-ve	+ve	-ve
4	Phenols	Ferric chloride test	-ve	+ve	-ve
5	Tannins	Gelatin test	-ve	+ve(mild)	-ve
6	Flavonoids	Alkaline reagent test	-ve	+ve	-ve
		Lead acetate test	-ve	+ve(mild)	-ve
7	Quinones	NAOH + Extract	-ve	-ve	-ve
	Gum & Mucilage	Extract + Alcohol	-ve	-ve	-ve
8	Diterpenes	Copper acetate test	-ve	+ve(mild)	-ve

Table 6: HPTLC analysis of Vellai kungiliyam purified by 3 different methods

S.no	Sample 1 Max rf	Sample 2 Max rf	Sample 3 Max rf
1.	0.06	0.01	0.01
2.	0.19	0.26	0.06
3.	0.40	0.34	0.09
4.	0.68	0.42	0.23
5.	1.00	0.58	0.40
6.	-	-	0.67
7.	-	-	0.89



Fig 1: Purification method 1



Fig 2: Purification method 2





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Fig 3: Pittaviyal murai



Fig 4: Wax-like consistency of Vellai kungiliyam

Purification method 3



Fig 5: sample I



Fig 6: sample II



Fig 7: sample III

Phytochemical Analysis study report

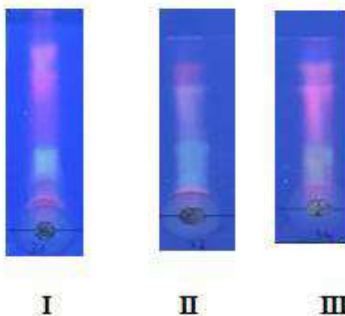
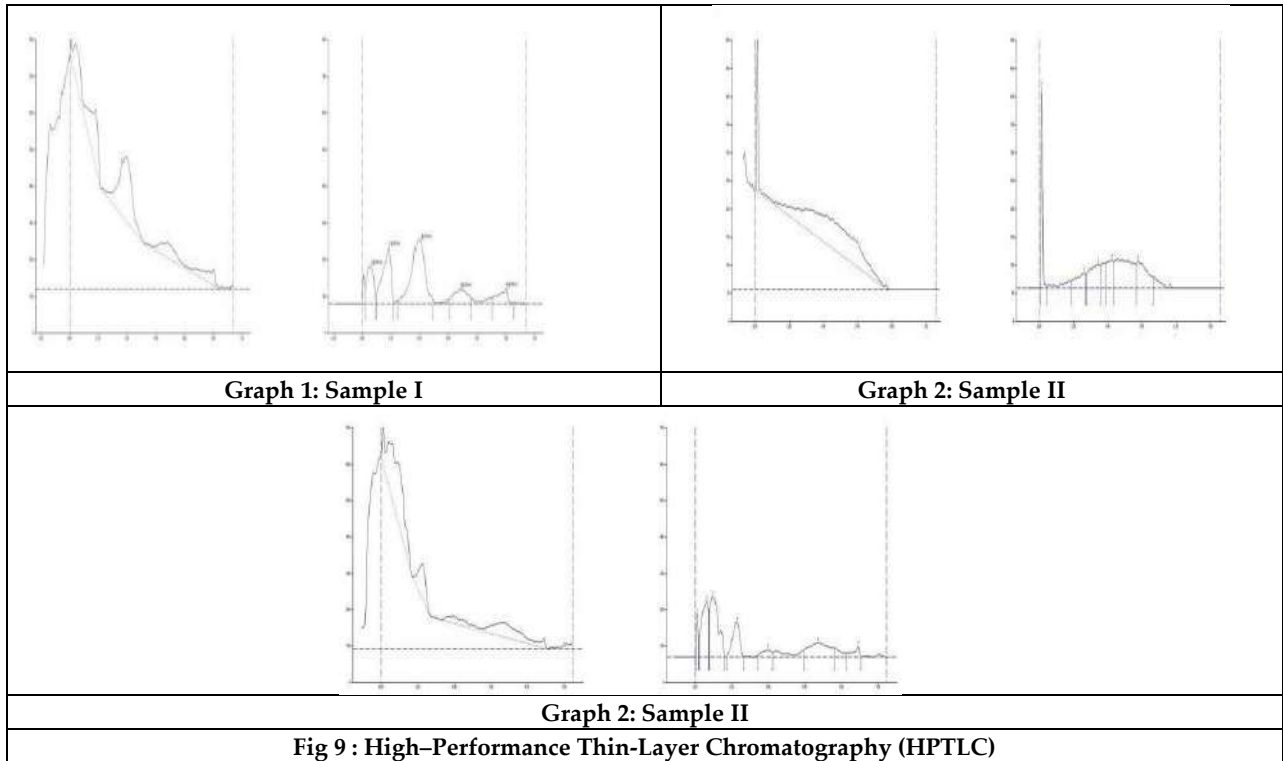


Fig 8: TLC Visualization of Sample I, Sample II, & Sample III at 366nm





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Product Signed Domination in Corona Product of Graphs - II

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ABSTRACT

Graph theory, a branch of mathematics deals with network of vertices connected by edges. Domination in graphs is one of the important research areas in graph theory. The product signed dominating function assigns -1 or 1 to the vertices of a graph such that the product of functional values of the closed neighborhood of every vertex is one. This research paper studies the product signed dominating functions in the corona product of any simple undirected connected graph with complete graph on even number of vertices and deduce the exact values of their product signed domination number.

Keywords: Corona product of graphs, product signed dominating function, weight of a graph, minimum weight, product signed domination number.

AMS Subject Classification: 05C69.





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INTRODUCTION

Domination in graphs is one of the important research areas in graph theory. It has applications in several fields. Signed domination was introduced by Dunbar and others [1-4]. The concept of signed domination was studied in [5-9],[14]. The concept of product signed dominating function, PSDF [13], was introduced in [10]. In [11], PSDF for the corona product of path, cycle and star graph, with complete graph on odd number of vertices are discussed. PSDF for the corona product of complete graph and star graph is discussed in [12] and for probabilistic neural networks is discussed in [13]. Let G be any simple undirected connected graph on “ a ” vertices. This research paper includes the works which enumerates the values of product signed domination number of $G \circ K_b$ for different values of a and even b . Even b may or may not be divisible by 4. Hence there are two cases say $b \equiv 0(mod 4)$ and $b \not\equiv 0(mod 4)$. Hence the results are discussed in main cases relevant to b and correspondingly we consider 4 cases for a as $a < b$ (a is odd), $a \leq b$ (a is even), $a > b$ & $a = kb$ ($k > 1$) and $a > b$ & $a = kb + l$ ($k, l \geq 1$). And finally it is proved that $\gamma_{sign}^*(G \circ K_b) \leq 4$ where G is any simple undirected connected graph on “ a ” vertices and $b \equiv 0(mod 2)$. Here $V(G) = \{v_1, v_2, \dots, v_a\}$. In $G \circ K_b$, at every vertex of G , there is a complete graph on $b + 1$ vertices. Let $K_{b+1}^1, K_{b+1}^2, \dots, K_{b+1}^a$ be the complete graphs at v_1, v_2, \dots, v_a respectively. For $i = 1$ to a , let $V(G \circ K_b) = \{v_i, v_{ij} | 1 \leq i \leq a, 1 \leq j \leq b\}$ and $E(G \circ K_b) = E(G) \cup \{v_i v_{ij} | 1 \leq i \leq a, 1 \leq j \leq b\} \cup \{v_{ij} v_{ik} | j \neq k, 1 \leq j, k \leq b, 1 \leq i \leq a\}$

PRELIMINARIES

Definition 2.1

Let $G = (V, E)$ be simple undirected connected graph. A function $f: V \rightarrow \{-1, 1\}$ is a product signed dominating function [10], PSDF [13] if each vertex v in V satisfies the condition $f[v] = \prod_{u \in N[v]} f(u) = 1$ where $N[v]$ denotes the closed neighborhood of v . The weight of a graph G with respect to the function f is denoted by $w_f(G)$ [13], and defined as $w_f(G) = \sum_{v \in V} f(v)$. The product signed domination number of a graph G is the minimum positive weight of a PSDF and is denoted as $\gamma_{sign}^*(G)$.

Definition 2.2

The graph $G \circ H$ that results from taking one copy of G and $|V(G)|$ copies of H and connecting the i^{th} vertex of G to every vertex in the i^{th} copy of H is called the corona product of two graphs G and H .

Theorem 2.3

For $b \leq 4$, $\gamma_{sign}^*(K_b) = b$, the total number of vertices.

$$\text{For } b > 4, \gamma_{sign}^*(K_b) = \begin{cases} 1 & \text{if } b \text{ is odd and } \frac{b-1}{2} \text{ is even} \\ 2 & \text{if } b \text{ is even and } \frac{b}{2} \text{ is odd} \\ 3 & \text{if } b \text{ and } \frac{b-1}{2} \text{ are odd} \\ 4 & \text{if } b \text{ and } \frac{b}{2} \text{ are even} \end{cases}$$

MAIN RESULTS

Observation 3.1

- (i) Let $f: V(G \circ K_b) \rightarrow \{-1, 1\}$. At each $v_i, 1 \leq i \leq a$, assigning -1 to zero or even number of vertices of K_{b+1}^i with $f(v_i) = 1, 1 \leq i \leq a$ leads to a PSDF.
- (ii) Since $b + 1$ is odd, atleast one vertex in every K_{b+1}^i where $1 \leq i \leq a$ should be assigned 1 in any PSDF.





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Theorem 3.2

Let b be an even positive integer such that $b \equiv 0(mod 4)$ and $a < b$ be an odd integer. Then, $\gamma_{sign}^*(G \circ K_b) = \begin{cases} 3 & \text{if } b - (a + 1) \equiv 0(mod 4) \\ 1 & \text{otherwise} \end{cases}$

Proof

Case 1: $b - (a + 1) \equiv 0(mod 4)$

If $a = 1$, then $b - (a + 1) = b - 2 \not\equiv 0(mod 4)$ since $b \equiv 0(mod 4)$. Hence $a > 1$.

Define $f: V(G \circ K_b) \rightarrow \{-1, 1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 & \text{if } \begin{matrix} 1 \leq i \leq a-1, 1 \leq j \leq \frac{b}{2} \\ \text{or} \\ i=a, 1 \leq j \leq \frac{b+a-3}{2} \end{matrix} \\ 1 & \text{otherwise} \end{cases}$$

$b \equiv 0(mod 4)$ and $b - (a + 1) \equiv 0(mod 4)$ implies $\frac{b+a-3}{2}$ is even.

Here $f[v] = 1 \forall v \in V(G \circ K_b)$

$$\text{Correspondingly, } w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 3$$

Further f is defined such that in $a - 1$ copies of K_{b+1} 's, $\sum_{j=1}^b f(v_{ij})$ vanishes for each i . Also $f(v_i) = 1 \forall i, 1 \leq i \leq a$. In the remaining a^{th} copy of K_{b+1} , v_{aj} 's, $1 \leq j \leq b$ are assigned -1 and 1 in such a way to get minimum positive weight.

Case 2: $b - (a + 1) \not\equiv 0(mod 4)$

When $a = 1$, $G \circ K_b \cong K_{b+1}$. Here $b + 1$ is odd and $b \equiv 0(mod 4)$ implies $\frac{b}{2}$ is even. Then by [2.3], $\gamma_{sign}^*(G \circ K_b) = 1$.

Let $a > 1$.

Define $f: V(G \circ K_b) \rightarrow \{-1, 1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 & \text{if } \begin{matrix} 1 \leq i \leq a-1, 1 \leq j \leq \frac{b}{2} \\ \text{or} \\ i=a, 1 \leq j \leq \frac{b+a-1}{2} \end{matrix} \\ 1 & \text{otherwise} \end{cases}$$

$b \equiv 0(mod 4), a + 1 \equiv 0(mod 2)$ and $b - (a + 1) \not\equiv 0(mod 4)$ implies $a + 1 \equiv 2(mod 4)$ and $\frac{b+a-1}{2}$ is even.

Here $f[v] = 1 \forall v \in V(G \circ K_b)$

$$\text{Correspondingly, } w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 1$$

Obviously, $w_f(G \circ K_b) = 1$ is minimum.

Hence the theorem.

Theorem 3.3

Let b be a positive integer such that $b \equiv 0(mod 4)$ and $a \leq b$ be an even integer. Then,

$$\gamma_{sign}^*(G \circ K_b) = \begin{cases} 4 & \text{if } b - a \equiv 0(mod 4) \\ 2 & \text{otherwise} \end{cases}$$

Proof

Case 1: $a = b$

Then $b - a \equiv 0(mod 4)$

Define $f: V(G \circ K_b) \rightarrow \{-1, 1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 & \text{if } \begin{matrix} 1 \leq i \leq a-1, 1 \leq j \leq \frac{b}{2} \\ \text{or} \\ i=a, 1 \leq j \leq b-2 \end{matrix} \\ 1 & \text{otherwise} \end{cases} \quad \dots (A)$$

Here $f[v] = 1 \forall v \in V(G \circ K_b)$

$$\text{Correspondingly, } w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 4$$





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Here f is defined such that in $a - 1$ copies of K_{b+1}^i , $\sum_{j=1}^b f(v_{ij})$ vanishes for each i . Also $f(v_i) = 1 \forall i, 1 \leq i \leq a$, $\sum_{i=1}^a f(v_i) = a$. And since $a = b$, if v_{aj} 's where $1 \leq j \leq b$ are assigned -1 , then, it is also a PSDF but the weight would be zero. So in order to get positive weight, f is defined as in (A). Therefore, $w_f(G \circ K_b) = 4$ is minimum.

Case 2: $a < b$

Subcase 2a: $b - a \equiv 0 \pmod{4}$

Define $f: V(G \circ K_b) \rightarrow \{-1, 1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 \text{ if } & \begin{matrix} 1 \leq i \leq a-1, 1 \leq j \leq \frac{b}{2} \\ \text{or} \\ i=a, \frac{b-a+4}{2} + 1 \leq j \leq b \end{matrix} \\ 1 \text{ otherwise} \end{cases} \quad \text{--- (B)}$$

$b \equiv 0 \pmod{4}, a \equiv 0 \pmod{2}$ and $b - a \equiv 0 \pmod{4}$ implies $\frac{b+a-4}{2}$ is even.

Here $f[v] = 1 \forall v \in V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 4$

Subcase 2b: $b - a \not\equiv 0 \pmod{4}$

Define $f: V(G \circ K_b) \rightarrow \{-1, 1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 \text{ if } & \begin{matrix} 1 \leq i \leq a-1, 1 \leq j \leq \frac{b}{2} \\ \text{or} \\ i=a, \frac{b-a+2}{2} + 1 \leq j \leq b \end{matrix} \\ 1 \text{ otherwise} \end{cases} \quad \text{---(C)}$$

$b \equiv 0 \pmod{4}, a \equiv 0 \pmod{2}$ and $b - a \not\equiv 0 \pmod{4}$ implies $\frac{b+a-2}{2}$ is even.

Here $f[v] = 1 \forall v \in V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 2$

In both the subcases 2a and 2b, f is defined such that in $a - 1$ copies of K_{b+1}^i 's, $\sum_{j=1}^b f(v_{ij})$ vanishes for each i . Also $f(v_i) = 1 \forall i, 1 \leq i \leq a$. In the remaining a^{th} copy of K_{b+1}^i , v_{aj} 's, $1 \leq j \leq b$ are assigned -1 and 1 depending on the value of $\frac{b-a}{2}$ in order to get minimum positive weight.

Hence the theorem.

The following theorems discuss the cases when $a > b$ and $b \equiv 0 \pmod{4}$.

Theorem 3.4

Let b be a positive integer such that $b \equiv 0 \pmod{4}$. Let $a > b$ be given by $a = kb$ where $k > 1$. Then, $\gamma_{\text{sign}}^*(G \circ K_b) = 4$.

Proof

Define $f: V(G \circ K_b) \rightarrow \{-1, 1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 \text{ if } & \begin{matrix} 1 \leq i \leq k, 1 \leq j \leq b \\ \text{or} \\ k+1 \leq i \leq a-1, 1 \leq j \leq \frac{b}{2} \\ \text{or} \\ i=a, 1 \leq j \leq \frac{b-4}{2} \end{matrix} \\ 1 \text{ otherwise} \end{cases}$$

$b \equiv 0 \pmod{4}$ implies $\frac{b}{2}$ is even and $\frac{b-4}{2}$ is even and $f[v] = 1 \forall v \in V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 4$

Here f is defined such that for k copies of K_{b+1}^i 's, $f(v_{ij}) = -1$ where $1 \leq j \leq b$ so that $(k)(b)(-1)$ vanishes with functional values of $(k)(b)$ vertices of v_i 's and in another $a - k - 1$ copies of K_{b+1}^i 's, the vertices v_{ij} 's, where $1 \leq j \leq b$, are assigned functional values such that its sum vanishes. And in the remaining one copy of K_{b+1}^i , v_{ij} 's, where $1 \leq j \leq b$, are assigned functional values which sums to 4 which is minimum.

Hence the theorem.





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Theorem 3.5

Let b be a positive integer such that $b \equiv 0(mod 4)$ and $a = kb + l$ where k and l are positive integers such that

$$k, l \geq 1. \text{ Then, } \gamma_{sign}^*(G \circ K_b) = \begin{cases} 4 \text{ if } l \equiv 0(mod 4) \\ 1 \text{ if } l \equiv 1(mod 4) \\ 2 \text{ if } l \equiv 2(mod 4) \\ 3 \text{ if } l \equiv 3(mod 4) \end{cases}$$

Proof

Here f is to be defined such that for k copies of K_{b+1}^i 's, $f(v_{ij}) = -1$ where $1 \leq j \leq b$ so that $(k)(b)(-1)$ vanishes with functional values of $(k)(b)$ vertices of v_i 's and in another $a - k - 1$ copies of K_{b+1}^i 's, the vertices v_{ij} 's, where $1 \leq j \leq b$, are assigned functional values such that its sum vanishes. And in the remaining one copy of K_{b+1}^i , functional values are to be assigned depending on the values of l .

Hence the weight would be $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v)$

$$\begin{aligned} &= \sum_{i=1}^a f(v_i) + \sum_{i=1}^a \sum_{j=1}^b f(v_{ij}) \\ &= a + \sum_{i=1}^k \sum_{j=1}^b f(v_{ij}) + \sum_{i=k+1}^{a-1} \sum_{j=1}^{\frac{b}{2}} f(v_{ij}) + \sum_{i=k+1}^{a-1} \sum_{j=\frac{b}{2}+1}^b f(v_{ij}) + \sum_{j=1}^b f(v_{aj}) \\ &= a + [(kb)(-1)] + \left[(a - 1 - k) \left(\frac{b}{2} \right) (-1) \right] + \left[(a - 1 - k) \left(\frac{b}{2} \right) (1) \right] + \sum_{j=1}^b f(v_{aj}) \\ &= a - kb + \sum_{j=1}^b f(v_{aj}) \\ &= l + \sum_{j=1}^b f(v_{aj}) \text{ since } a = kb + l \\ w_f(G \circ K_b) &= l + x \text{ where } x = \sum_{j=1}^b f(v_{aj}) \end{aligned} \tag{D}$$

The value of x depends on the value of l .

Case 1: $l \equiv 0(mod 4)$

Define $f: V(G \circ K_b) \rightarrow \{-1, 1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 \text{ if } \begin{matrix} 1 \leq i \leq k, 1 \leq j \leq b \\ \text{or} \\ k+1 \leq i \leq a-1, 1 \leq j \leq \frac{b}{2} \\ \text{or} \\ i=a, 1 \leq j \leq \frac{b+l-4}{2} \end{matrix} \\ 1 \text{ otherwise} \end{cases} \tag{E}$$

$b \equiv 0(mod 4)$ and $l \equiv 0(mod 4)$ implies $\frac{b}{2}$ and $\frac{b+l-4}{2}$ are even.

Also $f[v] = 1 \forall v \in V(G \circ K_b)$

$$w_f(G \circ K_b) = l + x \text{ where } x = \sum_{j=1}^b f(v_{aj}) \tag{by (D)}$$

$$\begin{aligned} &= l + \sum_{j=1}^{\frac{b+l-4}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-4}{2}+1}^b f(v_{aj}) \tag{by (E)} \\ &= l + \left(\frac{b+l-4}{2} \right) (-1) + \left(\frac{b-l+4}{2} \right) (1) \\ &= 4 \end{aligned}$$

Since f in (E) is defined to satisfy (D), the obtained weight is minimum.

Case 2: $l \equiv 1(mod 4)$

Define $f: V(G \circ K_b) \rightarrow \{-1, 1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 \text{ if } \begin{matrix} 1 \leq i \leq k, 1 \leq j \leq b \\ \text{or} \\ k+1 \leq i \leq a-1, 1 \leq j \leq \frac{b}{2} \\ \text{or} \\ i=a, 1 \leq j \leq \frac{b+l-1}{2} \end{matrix} \\ 1 \text{ otherwise} \end{cases} \tag{F}$$





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$b \equiv 0 \pmod{4}$ and $l - 1 \equiv 0 \pmod{4}$ implies $\frac{b}{2}$ and $\frac{b+l-1}{2}$ are even.

Also $f[v] = 1 \forall v \in V(G \circ K_b)$

$$w_f(G \circ K_b) = l + x \text{ where } x = \sum_{j=1}^b f(v_{aj}) \quad \text{(by (D))}$$

$$= l + \sum_{j=1}^{\frac{b+l-1}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-1}{2}+1}^b f(v_{aj}) \quad \text{(by (F))}$$

$$= l + \left(\frac{b+l-1}{2}\right)(-1) + \left(\frac{b-l+1}{2}\right)(1) = 1$$

Clearly, the weight is minimum.

Case 3: $l \equiv 2 \pmod{4}$

Define $f: V(G \circ K_b) \rightarrow \{-1,1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 & \text{if } \begin{matrix} 1 \leq i \leq k, 1 \leq j \leq b \\ \text{or} \\ k+1 \leq i \leq a-1, 1 \leq j \leq \frac{b}{2} \\ \text{or} \\ i=a, 1 \leq j \leq \frac{b+l-2}{2} \end{matrix} \\ 1 & \text{otherwise} \end{cases} \quad \text{--- (G)}$$

$b \equiv 0 \pmod{4}$ and $l - 2 \equiv 0 \pmod{4}$ implies $\frac{b}{2}$ and $\frac{b+l-2}{2}$ are even.

Also $f[v] = 1 \forall v \in V(G \circ K_b)$

$$w_f(G \circ K_b) = l + x \text{ where } x = \sum_{j=1}^b f(v_{aj}) \quad \text{(by (D))}$$

$$= l + \sum_{j=1}^{\frac{b+l-2}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-2}{2}+1}^b f(v_{aj}) \quad \text{(by (G))}$$

$$= l + \left(\frac{b+l-2}{2}\right)(-1) + \left(\frac{b-l+2}{2}\right)(1) = 2$$

Since f in (G) is defined to satisfy (D), the obtained weight is minimum.

Case 4: $l \equiv 3 \pmod{4}$

Define $f: V(G \circ K_b) \rightarrow \{-1,1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 & \text{if } \begin{matrix} 1 \leq i \leq k, 1 \leq j \leq b \\ \text{or} \\ k+1 \leq i \leq a-1, 1 \leq j \leq \frac{b}{2} \\ \text{or} \\ i=a, 1 \leq j \leq \frac{b+l-3}{2} \end{matrix} \\ 1 & \text{otherwise} \end{cases} \quad \text{--- (H)}$$

$b \equiv 0 \pmod{4}$ and $l - 3 \equiv 0 \pmod{4}$ implies $\frac{b}{2}$ and $\frac{b+l-3}{2}$ are even.

Also $f[v] = 1 \forall v \in V(G \circ K_b)$

$$w_f(G \circ K_b) = l + x \text{ where } x = \sum_{j=1}^b f(v_{aj}) \quad \text{(by (D))}$$

$$= l + \sum_{j=1}^{\frac{b+l-3}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-3}{2}+1}^b f(v_{aj}) \quad \text{(by (H))}$$

$$= l + \left(\frac{b+l-3}{2}\right)(-1) + \left(\frac{b-l+3}{2}\right)(1) = 3$$

Since f in (H) is defined to satisfy (D), the obtained weight is minimum.

Hence the theorem.

Remark 3.6:

In theorem 3.5, the values of k and l may or may not be equal.

The following theorems discuss the cases when $b \not\equiv 0 \pmod{4}$ is an even positive integer.

Theorem 3.7:

Let b be an even positive integer such that $b \not\equiv 0 \pmod{4}$ and $a < b$ be an odd integer. Then, $\gamma_{sign}^*(G \circ K_b) = \begin{cases} 3 & \text{if } b - (a + 1) \equiv 0 \pmod{4} \\ 1 & \text{otherwise} \end{cases}$





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Proof:

Here $b \not\equiv 0(mod 4)$ is an even integer implies $b \equiv 2(mod 4)$.

Let $f: V(G \circ K_b) \rightarrow \{-1,1\}$. f is to be defined such that f values of v_{ij} 's, where $1 \leq j \leq b$ at each i in $\frac{a-1}{2}$ copies of K_{b+1} 's vanishes with f values of v_{ij} 's, where $1 \leq j \leq b$ in another set of $\frac{a-1}{2}$ copies of K_{b+1} 's. in the remaining one copy, functional values are assigned depending on the value of $\frac{b-(a+1)}{2}$ --- (I)

Case 1: $b - (a + 1) \equiv 0(mod 4)$

Subcase 1a: $a = 1$

When $a = 1$, $G \circ K_b \cong K_{b+1}$. Here $b + 1$ is odd. $b \not\equiv 0(mod 4)$ is an even integer implies $\frac{b}{2}$ is odd. Then by 2.3, $\gamma_{sign}^*(G \circ K_b) = 3$.

Subcase 1b: $a > 1$

Define

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 \text{ if } & \begin{matrix} 1 \leq i \leq \frac{a-1}{2}, 1 \leq j \leq b \\ \text{or} \\ i=a, 1 \leq j \leq \frac{b+a-3}{2} \end{matrix} \\ 1 \text{ otherwise} \end{cases}$$

$b \equiv 2(mod 4), a \equiv 1(mod 2)$ and $b - (a + 1) \equiv 0(mod 4)$ implies $\frac{b+a-3}{2}$ is even.

Also $f[v] = 1 \forall v \in V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 3$

Since f is defined in such a way to satisfy (I), the obtained weight is minimum.

Case 2: $b - (a + 1) \not\equiv 0(mod 4)$

If $a = 1$, then $b - (a + 1) = b - 2 \equiv 0(mod 4)$ since $b \not\equiv 0(mod 4)$ is an even integer. Hence $a > 1$.

Define

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 \text{ if } & \begin{matrix} 1 \leq i \leq \frac{a-1}{2}, 1 \leq j \leq b \\ \text{or} \\ i=a, 1 \leq j \leq \frac{b+a-1}{2} \end{matrix} \\ 1 \text{ otherwise} \end{cases}$$

$b \equiv 2(mod 4), a \equiv 1(mod 2)$ and $b - (a + 1) \not\equiv 0(mod 4)$ implies $a + 1 \equiv 0(mod 4)$ and $\frac{b+a-1}{2}$ is even.

f is defined to satisfy (I) and here $f[v] = 1 \forall v \in V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 1$

Clearly, the weight is minimum.

Remark 3.8:

From 3.2 and 3.7, if $b \equiv 0(mod 2)$ and $a < b$ is an odd integer, then $\gamma_{sign}^*(G \circ K_b) = \begin{cases} 3 \text{ if } b - (a + 1) \equiv 0(mod 4) \\ 1 \text{ otherwise} \end{cases}$

Theorem 3.9:

Let b be an even positive integer such that $b \not\equiv 0(mod 4)$ and $a \leq b$ be even. Then,

$$\gamma_{sign}^*(G \circ K_b) = \begin{cases} 2 \text{ if } b - a \equiv 0(mod 4) \\ 4 \text{ otherwise} \end{cases}$$

Proof:

Here $b \not\equiv 0(mod 4)$ is an even integer implies $b \equiv 2(mod 4)$.

Case 1: $a = b$

Then $b - a \equiv 0(mod 4)$

Define $f: V(G \circ K_b) \rightarrow \{-1,1\}$ by





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$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 \text{ if } \frac{a-2}{2} + 1 \leq i \leq a-1, 1 \leq j \leq b \\ \text{or} \\ i=a, 1 \leq j \leq \frac{b-2}{2} \\ 1 \text{ otherwise} \end{cases}$$

Here $b \equiv 2 \pmod{4}$ implies $\frac{b-2}{2}$ is even. Also $f[v] = 1 \forall v \in V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 2$

Here f is defined such that f values of v_{ij} 's, where $1 \leq j \leq b$ at each i in one set of $\frac{a-2}{2}$ copies of K_{b+1}^i 's vanishes with f values of v_{ij} 's, where $1 \leq j \leq b$ in another set of $\frac{a-2}{2}$ copies of K_{b+1}^i 's and f values at each v_i , where $1 \leq i \leq a$ vanishes with f values at another one copy of K_{b+1}^i in which v_{ij} 's are assigned -1 . For the remaining one copy of K_{b+1}^i , functional values are assigned in order to get minimum weight that is positive. Hence, the weight obtained here is minimum.

Case 2: $a < b$

Subcase 2a: $b - a \equiv 0 \pmod{4}$

Define $f: V(G \circ K_b) \rightarrow \{-1, 1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 \text{ if } 1 \leq i \leq \frac{a-2}{2}, 1 \leq j \leq b \\ \text{or} \\ i=a-1, 1 \leq j \leq \frac{b-2}{2} \\ \text{or} \\ i=a, 1 \leq j \leq \frac{b+a}{2} \\ 1 \text{ otherwise} \end{cases}$$

$b \equiv 2 \pmod{4}$, $a \equiv 0 \pmod{2}$ and $b - a \equiv 0 \pmod{4}$ implies $a \equiv 2 \pmod{4}$ and $\frac{b+a}{2}$ is even.

Also $f[v] = 1 \forall v \in V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 2$

Here f is defined such that f values of v_{ij} 's, where $1 \leq j \leq b$ at each i in one set of $\frac{a-2}{2}$ copies of K_{b+1}^i 's vanishes with f values of v_{ij} 's, where $1 \leq j \leq b$ in another set of $\frac{a-2}{2}$ copies of K_{b+1}^i 's and f values at each v_i , where $1 \leq i \leq a$ vanishes with f values of v_{aj} 's, $1 \leq j \leq a < b$ and the remaining v_{aj} 's are assigned 1 and -1 equal number of times so that it sums to zero. In the remaining one copy of K_{b+1}^i , v_{ij} 's are assigned functional values which adds 2 to the weight. Hence, the weight obtained here is minimum.

Subcase 2b: $b - a \not\equiv 0 \pmod{4}$

Define $f: V(G \circ K_b) \rightarrow \{-1, 1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 \text{ if } 1 \leq i \leq \frac{a-2}{2}, 1 \leq j \leq b \\ \text{or} \\ i=a-1, 1 \leq j \leq \frac{b-2}{2} \\ \text{or} \\ i=a, 1 \leq j \leq \frac{b+a-2}{2} \\ 1 \text{ otherwise} \end{cases}$$

$b \equiv 2 \pmod{4}$, $a \equiv 0 \pmod{2}$ and $b - a \not\equiv 0 \pmod{4}$ implies $a \equiv 0 \pmod{4}$ and $\frac{b-2}{2}$ and $\frac{b+a-2}{2}$ are even.

Also $f[v] = 1 \forall v \in V(G \circ K_b)$

Correspondingly, $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 4$

Here f is defined such that f values of v_{ij} 's, where $1 \leq j \leq b$ at each i in one set of $\frac{a-2}{2}$ copies of K_{b+1}^i 's vanishes with f values of v_{ij} 's, where $1 \leq j \leq b$ in another set of $\frac{a-2}{2}$ copies of K_{b+1}^i 's and f values at each v_i , where $1 \leq i \leq a$ vanishes with f values of v_{aj} 's, $1 \leq j \leq a < b$ and the remaining v_{aj} 's are assigned functional values so that it sums to 2. In the remaining one copy of K_{b+1}^i , v_{ij} 's are assigned functional values which adds 2 to the weight. Hence, the weight obtained here is minimum.

Theorem 3.10

Let b be an even positive integer such that $b \not\equiv 0 \pmod{4}$. Let $a = kb$ where $k > 1$ be any positive integer. Then,

$$\gamma_{sign}^*(G \circ K_b) = \begin{cases} 4 \text{ if } a - k \equiv 0 \pmod{2} \\ 2 \text{ otherwise} \end{cases}$$





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Proof

b which is an even positive integer such that $b \not\equiv 0(mod 4)$ implies $b \equiv 2(mod 4)$.

Since $a = kb$, f is to be defined such that f values of v_{ij} 's, where $1 \leq j \leq b$ at k copies of K_{b+1}^i 's vanishes with f values of v_i 's where $1 \leq i \leq kb = a$. In the remaining $a - k$ copies of K_{b+1}^i 's, functional values for v_{ij} 's, where $1 \leq j \leq b$ are to be defined depending on the value of $a - k$. --- (J)

Case 1: $a - k \equiv 0(mod 2)$

Define $f: V(G \circ K_b) \rightarrow \{-1,1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 & \text{if } 1 \leq i \leq \frac{a+k-2}{2}, 1 \leq j \leq b \\ & \text{or } a-1 \leq i \leq a, 1 \leq j \leq \frac{b-2}{2} \\ 1 & \text{otherwise} \end{cases} \quad \text{--- (K)}$$

$b \equiv 2(mod 4)$ implies $\frac{b-2}{2}$ is even and $f[v] = 1 \forall v \in V(G \circ K_b)$

$$w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 4$$

Since (K) is defined to satisfy (J), the obtained weight is minimum.

Case 2: $a - k \not\equiv 0(mod 2)$

Define $f: V(G \circ K_b) \rightarrow \{-1,1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 & \text{if } 1 \leq i \leq \frac{a+k-1}{2}, 1 \leq j \leq b \\ & \text{or } i=a, 1 \leq j \leq \frac{b-2}{2} \\ 1 & \text{otherwise} \end{cases} \quad \text{--- (L)}$$

$b \equiv 2(mod 4)$ implies $\frac{b-2}{2}$ is even and $f[v] = 1 \forall v \in V(G \circ K_b)$

$$w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v) = 2$$

Since (L) is defined to satisfy (J), the obtained weight is minimum.

Hence the theorem.

Theorem 3.11

Let b be an even positive integer such that $b \not\equiv 0(mod 4)$. Let $a = kb + l$ where $k \geq 1, l \geq 1$ be any integers. Let m_1 denote $\gamma_{sign}^*(G \circ K_b)$ when $a - k \not\equiv 0(mod 2)$ and m_2 denote $\gamma_{sign}^*(G \circ K_b)$ when $a - k \equiv 0(mod 2)$ Then,

$$m_1 = \begin{cases} m_{11} = 2 & \text{if } l \equiv 0(mod 4) \\ m_{12} = 3 & \text{if } l \equiv 1(mod 4) \\ m_{13} = 4 & \text{if } l \equiv 2(mod 4) \\ m_{14} = 1 & \text{if } l \equiv 3(mod 4) \end{cases} \quad \text{and } m_2 = \begin{cases} m_{11} + 2 & \text{if } l \equiv 0(mod 4) \\ m_{12} - 2 & \text{if } l \equiv 1(mod 4) \\ m_{13} - 2 & \text{if } l \equiv 2(mod 4) \\ m_{14} + 2 & \text{if } l \equiv 3(mod 4) \end{cases}$$

Proof

b which is an even positive integer such that $b \not\equiv 0(mod 4)$ implies $b \equiv 2(mod 4)$.

Case 1: $a - k \not\equiv 0(mod 2)$

f is to be defined such that f values of v_{ij} 's, where $1 \leq j \leq b$ in one set of $\frac{a-k-1}{2}$ copies of K_{b+1}^i 's vanishes with f values of v_{ij} 's, where $1 \leq j \leq b$ in another set of $\frac{a-k-1}{2}$ copies of K_{b+1}^i 's. And in another k copies of K_{b+1}^i 's, v_{ij} 's, where $1 \leq j \leq b$ are assigned -1 so that it vanishes with f values of v_i 's where $1 \leq i \leq kb$. In the remaining one copy, v_{ij} 's, where $1 \leq j \leq b$ are assigned functional values depending on the value of l .

Correspondingly, the weight would be $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v)$

$$= \sum_{i=1}^a f(v_i) + \sum_{i=1}^a \sum_{j=1}^b f(v_{ij})$$





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$$\begin{aligned}
 &= a + \sum_{i=1}^{\frac{a-k-1}{2}} \sum_{j=1}^b f(v_{ij}) + \sum_{i=\frac{a-k-1}{2}+1}^{a-1} \sum_{j=1}^b f(v_{ij}) + \sum_{j=1}^b f(v_{aj}) \\
 &= a + \left[\left(\frac{a-k-1}{2} \right) (b)(1) \right] + \left[\left(\frac{a+k-1}{2} \right) (b)(-1) \right] + \sum_{j=1}^b f(v_{aj}) \\
 &= a - kb + \sum_{j=1}^b f(v_{aj}) \\
 &= l + \sum_{j=1}^b f(v_{aj}) \quad \text{since } a = kb + l \\
 w_f(G \circ K_b) &= l + x \text{ where } x = \sum_{j=1}^b f(v_{aj}) \quad \text{--- (M)}
 \end{aligned}$$

Subcase 1a: $l \equiv 0 \pmod{4}$

Define $f: V(G \circ K_b) \rightarrow \{-1,1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 \text{ if } \frac{a-k-1}{2}+1 \leq i \leq a-1, 1 \leq j \leq b \\ \text{or} \\ i=a, 1 \leq j \leq \frac{b+l-2}{2} \\ 1 \text{ otherwise} \end{cases} \quad \text{--- (N)}$$

$b \equiv 2 \pmod{4}, l-2 \equiv 2 \pmod{4}$ implies $\frac{b+l-2}{2}$ is even and $f[v] = 1 \forall v \in V(G \circ K_b)$

$$\begin{aligned}
 w_f(G \circ K_b) &= l + x \quad \text{(by (M))} \\
 &= l + \sum_{j=1}^{\frac{b+l-2}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-2}{2}+1}^b f(v_{aj}) \quad \text{(by (N))} \\
 &= l + \left[\left(\frac{b+l-2}{2} \right) (-1) \right] + \left[\left(\frac{b-l+2}{2} \right) (1) \right] = 2 = m_{11}
 \end{aligned}$$

Since (N) is defined to satisfy (M), the obtained weight is minimum.

Subcase 1b: $l \equiv 1 \pmod{4}$

Define $f: V(G \circ K_b) \rightarrow \{-1,1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 \text{ if } \frac{a-k-1}{2}+1 \leq i \leq a-1, 1 \leq j \leq b \\ \text{or} \\ i=a, 1 \leq j \leq \frac{b+l-3}{2} \\ 1 \text{ otherwise} \end{cases} \quad \text{--- (O)}$$

$b \equiv 2 \pmod{4}, l \equiv 1 \pmod{4}$ implies $\frac{b+l-3}{2}$ is even and $f[v] = 1 \forall v \in V(G \circ K_b)$

$$\begin{aligned}
 w_f(G \circ K_b) &= l + x \quad \text{(by (M))} \\
 &= l + \sum_{j=1}^{\frac{b+l-3}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-3}{2}+1}^b f(v_{aj}) \quad \text{(by (O))} \\
 &= l + \left[\left(\frac{b+l-3}{2} \right) (-1) \right] + \left[\left(\frac{b-l+3}{2} \right) (1) \right] = 3 = m_{12}
 \end{aligned}$$

Since (O) is defined to satisfy (M), the obtained weight is minimum.

Subcase 1c: $l \equiv 2 \pmod{4}$

Define $f: V(G \circ K_b) \rightarrow \{-1,1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 \text{ if } \frac{a-k-1}{2}+1 \leq i \leq a-1, 1 \leq j \leq b \\ \text{or} \\ i=a, 1 \leq j \leq \frac{b+l-4}{2} \\ 1 \text{ otherwise} \end{cases} \quad \text{--- (P)}$$

$b \equiv 2 \pmod{4}, l \equiv 2 \pmod{4}$ implies $\frac{b+l-4}{2}$ is even and $f[v] = 1 \forall v \in V(G \circ K_b)$

$$\begin{aligned}
 w_f(G \circ K_b) &= l + x \quad \text{(by (M))} \\
 &= l + \sum_{j=1}^{\frac{b+l-4}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-4}{2}+1}^b f(v_{aj}) \quad \text{(by (P))} \\
 &= l + \left[\left(\frac{b+l-4}{2} \right) (-1) \right] + \left[\left(\frac{b-l+4}{2} \right) (1) \right] = 4 = m_{13}
 \end{aligned}$$

Since (P) is defined to satisfy (M), the obtained weight is minimum.





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Subcase 1d: $l \equiv 3(mod 4)$

Define $f: V(G \circ K_b) \rightarrow \{-1,1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 \text{ if } \frac{a-k-1}{2}+1 \leq i \leq a-1, 1 \leq j \leq b \\ \text{or} \\ i=a, 1 \leq j \leq \frac{b+l-1}{2} \\ 1 \text{ otherwise} \end{cases} \quad \dots (Q)$$

$b \equiv 2(mod 4), l \equiv 3(mod 4)$ implies $\frac{b+l-1}{2}$ is even and $f[v] = 1 \forall v \in V(G \circ K_b)$

$w_f(G \circ K_b) = l + x$ (by (M))

$= l + \sum_{j=1}^{\frac{b+l-1}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-1}{2}+1}^b f(v_{aj})$ (by (Q))

$= l + \left[\left(\frac{b+l-1}{2} \right) (-1) \right] + \left[\left(\frac{b-l+1}{2} \right) (1) \right] = 1 = m_{14}$

Clearly, the weight is minimum.

Case 2: $a - k \equiv 0(mod 2)$

f is to be defined such that f values of v_{ij} 's, where $1 \leq j \leq b$ in one set of $\frac{a-k-2}{2}$ copies of K_{b+1} 's vanishes with f values of v_{ij} 's, where $1 \leq j \leq b$ in another set of $\frac{a-k-2}{2}$ copies of K_{b+1} 's. And in another k copies of K_{b+1} 's, v_{ij} 's, where $1 \leq j \leq b$ are assigned -1 so that it vanishes with f values of v_i 's where $1 \leq i \leq kb$. In the remaining two copies, v_{ij} 's, where $1 \leq j \leq b$ are assigned functional values depending on the value of l .

Correspondingly, the weight would be $w_f(G \circ K_b) = \sum_{v \in V(G \circ K_b)} f(v)$

$= \sum_{i=1}^a f(v_i) + \sum_{i=1}^a \sum_{j=1}^b f(v_{ij})$

$= a + \sum_{i=1}^{\frac{a-k-2}{2}} \sum_{j=1}^b f(v_{ij}) + \sum_{i=\frac{a-k-2}{2}+1}^{a-2} \sum_{j=1}^b f(v_{ij}) + \sum_{j=1}^b f(v_{(a-1)j}) + \sum_{j=1}^b f(v_{aj})$

$= a + \left[\left(\frac{a-k-2}{2} \right) (b)(1) \right] + \left[\left(\frac{a+k-2}{2} \right) (b)(-1) \right] + \sum_{j=1}^b f(v_{(a-1)j}) + \sum_{j=1}^b f(v_{aj})$

$= a - kb + \sum_{j=1}^b f(v_{(a-1)j}) + \sum_{j=1}^b f(v_{aj})$

$= l + \sum_{j=1}^b f(v_{(a-1)j}) + \sum_{j=1}^b f(v_{aj})$ since $a = kb + l$ Hence $w_f(G \circ K_p) = l + y$ where $y = \sum_{j=1}^b f(v_{(a-1)j}) + \sum_{j=1}^b f(v_{aj})$ --- (R)

Subcase 2a: $l \equiv 0(mod 4)$

Define $f: V(G \circ K_b) \rightarrow \{-1,1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 \text{ if } \frac{a-k-2}{2}+1 \leq i \leq a-2, 1 \leq j \leq b \\ \text{or} \\ i=a-1, 1 \leq j \leq \frac{b-2}{2} \\ \text{or} \\ i=a, 1 \leq j \leq \frac{b+l-2}{2} \\ 1 \text{ otherwise} \end{cases} \quad \dots (S)$$

$b \equiv 2(mod 4), l \equiv 0(mod 4)$ implies $\frac{b+l-2}{2}$ and $\frac{b-2}{2}$ are even and $f[v] = 1 \forall v \in V(G \circ K_b)$

$w_f(G \circ K_b) = l + y$ (by (R))

$= l + \sum_{j=1}^{\frac{b-2}{2}} f(v_{(a-1)j}) + \sum_{j=\frac{b-2}{2}+1}^b f(v_{(a-1)j}) + \sum_{j=1}^{\frac{b+l-2}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-2}{2}+1}^b f(v_{aj})$ (by (S))

$= l + \left[\left(\frac{b-2}{2} \right) (-1) \right] + \left[\left(\frac{b+2}{2} \right) (1) \right] + \left[\left(\frac{b+l-2}{2} \right) (-1) \right] + \left[\left(\frac{b-l+2}{2} \right) (1) \right]$
 $= 4 = m_{11} + 2$

Since (S) is defined to satisfy (R), the obtained weight is minimum.





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Subcase 2b: $l \equiv 1 \pmod{4}$

Define $f: V(G \circ K_b) \rightarrow \{-1,1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 \text{ if } & \frac{a-k-2}{2}+1 \leq i \leq a-2, 1 \leq j \leq b \\ & \text{or} \\ & i=a-1, 1 \leq j \leq \frac{b+2}{2} \\ & \text{or} \\ & i=a, 1 \leq j \leq \frac{b+l-3}{2} \\ & 1 \text{ otherwise} \end{cases} \quad \text{--- (T)}$$

$b \equiv 2 \pmod{4}, l \equiv 1 \pmod{4}$ implies $\frac{b+l-3}{2}$ and $\frac{b+2}{2}$ are even and $f[v] = 1 \forall v \in V(G \circ K_b)$

$w_f(G \circ K_b) = l + y$ (by (R))

$= l + \sum_{j=1}^{\frac{b+2}{2}} f(v_{(a-1)j}) + \sum_{j=\frac{b+2}{2}+1}^b f(v_{(a-1)j}) + \sum_{j=1}^{\frac{b+l-3}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-3}{2}+1}^b f(v_{aj})$ (by (T))

$= l + \left[\left(\frac{b+2}{2} \right) (-1) \right] + \left[\left(\frac{b-2}{2} \right) (1) \right] + \left[\left(\frac{b+l-3}{2} \right) (-1) \right] + \left[\left(\frac{b-l+3}{2} \right) (1) \right] = 1 = m_{12} - 2$

Clearly, the weight is minimum.

Subcase 2c: $l \equiv 2 \pmod{4}$

Define $f: V(G \circ K_b) \rightarrow \{-1,1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 \text{ if } & \frac{a-k-2}{2}+1 \leq i \leq a-2, 1 \leq j \leq b \\ & \text{or} \\ & i=a-1, 1 \leq j \leq \frac{b+2}{2} \\ & \text{or} \\ & i=a, 1 \leq j \leq \frac{b+l-4}{2} \\ & 1 \text{ otherwise} \end{cases} \quad \text{--- (U)}$$

$b \equiv 2 \pmod{4}, l \equiv 2 \pmod{4}$ implies $\frac{b+l-4}{2}$ and $\frac{b+2}{2}$ are even and $f[v] = 1 \forall v \in V(G \circ K_b)$

$w_f(G \circ K_b) = l + y$ (by (R))

$= l + \sum_{j=1}^{\frac{b+2}{2}} f(v_{(a-1)j}) + \sum_{j=\frac{b+2}{2}+1}^b f(v_{(a-1)j}) + \sum_{j=1}^{\frac{b+l-4}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-4}{2}+1}^b f(v_{aj})$ (by (U))

$= l + \left[\left(\frac{b+2}{2} \right) (-1) \right] + \left[\left(\frac{b-2}{2} \right) (1) \right] + \left[\left(\frac{b+l-4}{2} \right) (-1) \right] + \left[\left(\frac{b-l+4}{2} \right) (1) \right]$
 $= 2 = m_{13} - 2$

Since (U) is defined to satisfy (R), the obtained weight is minimum.

Subcase 2d: $l \equiv 3 \pmod{4}$

Define $f: V(G \circ K_b) \rightarrow \{-1,1\}$ by

$$f(v_i) = 1 \forall i, 1 \leq i \leq a \text{ and } f(v_{ij}) = \begin{cases} -1 \text{ if } & \frac{a-k-2}{2}+1 \leq i \leq a-2, 1 \leq j \leq b \\ & \text{or} \\ & i=a-1, 1 \leq j \leq \frac{b-2}{2} \\ & \text{or} \\ & i=a, 1 \leq j \leq \frac{b+l-1}{2} \\ & 1 \text{ otherwise} \end{cases} \quad \text{--- (V)}$$

$b \equiv 2 \pmod{4}, l \equiv 3 \pmod{4}$ implies $\frac{b+l-1}{2}$ and $\frac{b-2}{2}$ are even and $f[v] = 1 \forall v \in V(G \circ K_b)$

$w_f(G \circ K_b) = l + y$ (by (R))

$= l + \sum_{j=1}^{\frac{b-2}{2}} f(v_{(a-1)j}) + \sum_{j=\frac{b-2}{2}+1}^b f(v_{(a-1)j}) + \sum_{j=1}^{\frac{b+l-1}{2}} f(v_{aj}) + \sum_{j=\frac{b+l-1}{2}+1}^b f(v_{aj})$ (by (V))

$= l + \left[\left(\frac{b-2}{2} \right) (-1) \right] + \left[\left(\frac{b+2}{2} \right) (1) \right] + \left[\left(\frac{b+l-1}{2} \right) (-1) \right] + \left[\left(\frac{b-l+1}{2} \right) (1) \right]$
 $= 3 = m_{14} + 2$

Since (V) is defined to satisfy (R), the obtained weight is minimum.

Hence the theorem.

Remark 3.12:

In theorem 3.11, the values of k and l may or may not be equal.





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CONCLUSION

From the above results, it is clear that $\gamma_{sign}^*(G \circ K_b) \leq 4$ where G is any simple undirected graph on " a " vertices and $b \equiv 0 \pmod{2}$.

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Understanding Flunitrazepam : A Concise Review on Action Pathways and Adverse Effects

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ABSTRACT

Benzodiazepines (BZD) can cause a variety of adverse effects, ranging from nausea and vomiting to mental impairment and memory disturbances. Whereas none of the side effects are small enough to be neglected, memory deficiency, motor impairment and vasorelaxation are of utmost importance as they aid the abusers for its utilization as a date-rape drug. These adverse effects take place through action pathways that are yet to be completely uncovered. This review provides the highlights of three main pathways and their crucial roles for the above-mentioned adverse effects, respectively. The studies are based on the pathways of NO:cGMP, L-arginine NO:cGMP and Endothelial NO-dependent and endothelium-independent, which are found to regulate memory deficiency, motor impairment and vasorelaxant effects caused by FNZ, respectively. The common findings of these research studies indicate that NO-related mechanisms could be involved in FNZ produced motor and memory failure in rodents. Nitric oxide (NO), a key bioregulatory molecule, is produced from L-arginine through a reaction catalyzed by nitric oxide synthase (NOS) and is thought to be essential in regulating neuronal excitability, synaptic plasticity, anxiety, seizure activity, and drug tolerance. Moreover, FNZ has showed to have a clear vasodilatory effect in isolated rat thoracic aortas through both endothelial-NO-mediated and endothelium-independent pathways. This review aims to help in discovering a strategical method in blocking or reversing the mentioned adverse effects and terminating the use of flunitrazepam as date-rape drug. Hence, getting a better understanding of FNZ action pathways can be helpful in building tolerance towards its adverse effects and increasing its therapeutic efficacy.

Keywords: Benzodiazepines, flunitrazepam, nitric oxide, date-rape drug.



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INTRODUCTION

Flunitrazepam(FNZ), commonly known by the brand name Rohypnol, is a potent sedative-hypnotic drug belonging to the benzodiazepine class. It is a sedative–hypnotic benzodiazepine that is used for the short-term treatment of insomnia, for premedication in surgical procedures, and for inducing anesthesia[1].FNZ is one of the most commonly abused benzodiazepines; nevertheless, it is unclear if BZD abuse is recreational in character or an abnormal drug use related with the drug's therapeutic utility[2]. BZD can cause a variety of adverse effects, such as nausea, vomiting, drowsiness, confusion, dizziness, shaking, poor balance, and memory disturbances. Memory deficiency and motor impairment are one of the many side effects of BZD along with vasorelaxant effects.

Flunitrazepam is frequently misused in social environments mostly involving bars, clubs, etc., often to render individuals helpless for the purpose of sexual assault.It is typically slipped into a person's drink without their knowledge. When used as a roofie, flunitrazepam can cause sedation, confusion, impaired coordination, and anterograde amnesia, making it difficult for victims to remember what happened while under its influence[3-5].FNZ can induce anterograde amnesia, which prevents the patient from recollecting any memories of the past events that have occurred after ingestion of the drug. This feature lends itself to its use as a "date-rape drug," which is frequently delivered in a bar or party ("club drug"), where it is unknowingly put into the beverages of victims who will then have little or no recall of the assault[6].Detecting the presence of flunitrazepam in a person's system can be challenging, as it is rapidly metabolized and eliminated from the body. However, specialized toxicology tests can detect its presence in urine or blood samples.

FNZ acts on the central nervous system (CNS) by enhancing the effects of gamma-aminobutyric acid (GABA), a neurotransmitter that inhibits brain activity. The mechanism of action of FNZ involves its binding to the type A-aminobutyric acid receptor (GABAA-R), an intrinsic membrane protein. Allosteric binding of another medication or modification of lipid phase dynamics near a receptor can lead to the structural changes of its binding site. Thus, knowledge of the modulation of FNZ–membrane binding, including binding to GABAA-R, is required for proper development of functional methods to evaluate FNZ quantity and function simultaneously.

GABA ligands, such as barbiturates, can allosterically regulate FNZ binding depending on the subunit composition of the receptor. For example, pentobarbital and etomidate inhibit $\alpha 1\gamma 2$ receptor binding of FNZ, while the same compounds stimulate $\alpha 1\beta 3\gamma 3$ receptor binding[7]. Perhaps more concerning is the finding that FNZ can act as an inverse agonist on $\alpha 6\beta 2\gamma 2$ receptors, causing insomnia instead of sedation and anxiety instead of anxiolysis, respectively[8]. The paradoxical effects of FNZ, such as hyperactivity, insomnia, aggression, hallucinations, and anxiety, may be explained by this inverse agonist pharmacology. These subtle variations can explain why certain benzodiazepines, such as FNZ, are more likely to be abused or trigger a stronger amnesic effect, more potent anxiolysis, or a strong sedative effect.

To certain extent, all benzodiazepines potentiate GABA binding to their receptor and cause CNS depression, which is clinically manifested as sedative, anxiolytic, and amnesic actions (Griffin et. al, 2013). Flunitrazepam, a high-potency benzodiazepine,can be used as a hypnotic to produce anesthesia and have a stronger anterograde amnesia effect. This property attributes an individual's failure to memorize the events from the moment of administration (parenteral) or after enough absorption of the drug (oral). Small therapeutic dosages of FNZ administered either intravenously or orally can obviously cause memory impairment, however, this effect is transient and appears to fade within 30 minutes of drug administration. GABA_A receptor activation has been found to affect memory formation in the hippocampus formation. Long-term potentiation (LTP) involving the N-methyl-D-aspartate (NMDA) receptor involve the excitatory amino acid transmitters glutamate and aspartate in plastic changes in neurons of this cerebral. FNZ induced LTP induction can be blocked by pre-administration of flumazenil, benzodiazepine receptor antagonist[9]. FNZ also has considerable vasodilatory characteristic, viz. the vascular smooth muscle relaxation, blood pressure reduction and a reflex rise in heart rate. The above characteristic is unique



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to this benzodiazepine. According to a clinical investigation, it was found that 2 mg of FNZ causes pleasurable feelings in healthy people[10].

In addition to its illicit use, flunitrazepam can also lead to dependence and addiction when used recreationally or in high doses. Chronic use of the drug can result in tolerance, where higher doses are needed to achieve the same effects, as well as withdrawal symptoms upon discontinuation. Withdrawal from benzodiazepines, including FNZ, is marked by rebound anxiety or sleeplessness, which may be accompanied by headaches, nausea, vomiting, and muscle tremors[11-14].

CLINICAL USES

Flunitrazepam is sometimes used in the short-term management of severe anxiety or agitation. However, due to its sedative effects and potential for abuse, it is generally not recommended as a first-line treatment for anxiety disorders[15]. In some medical procedures, it is given as a sedative, such as endoscopy or minor surgery, to induce relaxation and reduce anxiety. It is administered under strict medical supervision due to its potential for misuse[16]. Flunitrazepam is primarily indicated for the short-term treatment of severe insomnia. It is used when other treatments have failed or are not suitable, and its use is limited to a few weeks due to the risk of tolerance and dependence[17]. It also has muscle relaxant properties which can be utilized in the management of muscle spasms or stiffness. However, its use is generally limited to short-term treatment due to the risk of adverse effects and dependence[18]. Flunitrazepam may be used as a pre-anesthetic medication to induce sedation and reduce anxiety before surgery. It is often administered intravenously or orally in this setting[19, 20]. In some cases of status epilepticus (a life-threatening condition characterized by prolonged seizures), flunitrazepam may be used as an adjunctive treatment to help control seizures. However, other medications are typically preferred for this indication. Due to its anticonvulsant properties, it may be used in the management of certain types of seizures, however, this is not always advised seeing the risks associated with it, and is only used when all the other options have been exhausted[21]. In cases where the use of FNZ is inevitable, a risk-benefit ratio assessment can be done.

MISUSE OF FLUNITRAZEPAM

The misuse of flunitrazepam, is a significant public health concern due to its potent sedative effects and potential for abuse. Moreover, flunitrazepam exhibits characteristics of central nervous system depressants by inducing relaxation, sedation, and amnesia.

One of the most notorious aspects of flunitrazepam misuse is its association with drug-facilitated sexual assault (DFSA). Due to its potent sedative effects and amnesia-inducing properties, flunitrazepam is often used by perpetrators to incapacitate victims, making them vulnerable to sexual assault[22]. The drug is typically slipped into drinks without the knowledge of victim, leading to loss of consciousness, memory impairment, and difficulties in recalling events, which can hinder the victim's ability to report the assault [23, 24]. One of the key factors contributing to flunitrazepam's notoriety as a date rape drug is its potency and rapid onset of action. When mixed with alcohol or other beverages, flunitrazepam can intensify the sedative effects, leading to a quick and profound impairment of cognitive and motor functions[25, 26].

FNZ is also misused for recreational purposes, particularly in settings where individuals seek to enhance the effects of alcohol or other drugs. Some individuals misuse flunitrazepam to experience some euphoric effects associated with it, which can induce feelings of relaxation and tranquillity. However, recreational use of flunitrazepam is associated with a high risk of dependence, tolerance, and overdose, especially when combined with other substances [27, 28].

Chronic misuse of FNZ can lead to the development of dependence, characterized by physical and psychological reliance on the drug to function normally[29]. Individuals who misuse flunitrazepam may experience withdrawal symptoms when attempting to reduce or discontinue its use, including anxiety, insomnia, tremors, seizures, and hallucinations[30, 31].

If taken in high doses or combined with other central nervous system depressants such as alcohol or opioids FNZ can cause overdose. This may lead to severe respiratory depression, coma, and even death. The risk of dependence,



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withdrawal and overdose underscores the importance of careful prescribing practices and monitoring of flunitrazepam use [32-35].

ACTION PATHWAYS FOR FLUNITRAZEPAM**L-Arginine:NO:cGMP Pathway**

According to Talarek S. et. al., they conducted some rotarod and chimney experiments using mice to assess the motor impairing effects of FNZ. It was found that both a non-selective nitric oxide synthase (NOS) inhibitor, NG-nitro-L-arginine methyl ester (L-NAME), and an unselective neuronal NOS inhibitor, 7-nitroindazole (7-NI), blocked the development of tolerance to the motor impairing effects of FNZ. Additionally, L-arginine, a precursor of nitric oxide (NO) and a potent inhibitor of phosphodiesterase 5 (PDE5), did not affect the development of tolerance to FNZ-induced motor dysfunction in mice, as evidenced by sildenafil's lack of impact [36, 37].

Nitric Oxide

Nitric oxide (NO) is a key bioregulatory molecule produced from L-arginine through a reaction catalyzed by nitric oxide synthase (NOS) as seen in Fig. 1. Since 2010, research has further elucidated the diverse roles of NO in neuronal function. NO is considered essential in regulating various aspects of neuronal activity, including excitability, synaptic plasticity, anxiety, seizure activity, and drug tolerance [38].

NO mediates its effects by increasing the expression of cyclic guanosine 3',5'-monophosphate (cGMP) and modulating cGMP-dependent signaling. Upon synthesis, NO allosterically interacts with soluble guanylyl cyclase (sGC), leading to the production of cGMP. This molecule then regulates various downstream effectors, including cGMP-dependent kinases, cGMP-gated ion channels, and cGMP-regulated phosphodiesterases (PDE).^[38] The modulation of these effectors by cGMP plays a crucial role in mediating the diverse effects of NO in neuronal physiology [39, 40].

L-arginine:NO:cGMP and GABA:

There is compelling evidence supporting a link between L-arginine: GABA-mediated transmission and the nitric oxide (NO):cGMP pathway in the central nervous system (CNS). Neurotransmitters such as nitric oxide (NO) and gamma-aminobutyric acid (GABA) play crucial roles in neuronal communication and are intricately interconnected. Studies have shown that neuronal nitric oxide synthase (NOS)-positive neurons are co-localized with GABA-positive neurons in various regions of the CNS, including the cerebral cortex and spinal cord, as revealed by histochemical mapping [41-43]. Activation of GABAergic neurotransmission has been shown to result in the production of NO in the animal cortex, highlighting the close relationship between these two systems [44]. Furthermore, NO has been shown to modulate GABA release and uptake in the CNS, suggesting a regulatory role for NO in GABAergic neurotransmission [45, 46]. This intricate interplay between L-arginine: GABA-mediated transmission and the NO:cGMP pathway underscores the complexity of neuronal signaling in the CNS.

Flunitrazepam has been shown to modulate the L-arginine:NO:cGMP pathway in the CNS. Studies have demonstrated that flunitrazepam can alter NO production and cGMP levels in the brain, suggesting a potential interaction with this pathway [47]. Flunitrazepam's effects on the L-arginine:NO:cGMP pathway may contribute to its pharmacological actions, including sedative-hypnotic and anxiolytic effects, by modulating neurotransmission and synaptic plasticity [48, 49].

According to a study conducted by Talarek et. al., using animal models, it was noticed that tolerance to motor impairment can be blocked with the use of nitro-L-arginine methyl ester (L-NAME) and 7-nitroindazole, both being indirect and direct inhibitors of nitric oxide synthase, respectively [50, 51]. Chronic administration of NOS inhibitors and FNZ is thought to prevent GABA-A receptor inhibition, thus helping manage symptoms related to cognition. The activation of N-methyl-D-aspartate (NMDA) receptors help to synthesize more amounts of NO [52, 53]. Drugs that function on the GABA-A receptors, (such as benzodiazepines, barbiturates, and alcohol) cause motor impairing



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effects. When NMDA receptor antagonists, (such as amantadine, ketamine and dextromethorphan) are given along with these drugs, the development of tolerance to their motor impairing effects is reduced. Hence, the investigation conducted by Talarek et. al., has gathered some behavioral evidence from animal models that the L-arginine:NO:cGMP pathway can play a key role in the development of FNZ tolerance.

NO-cGMP Pathway

BZDs can cause a variety of adverse effects, such as emesis, disorientation, confusion, dizziness, shaking, poor balance, and memory disturbances. Memory deficiency is one of the many side effects of BZDs, which restricts their use in conditions like anxiety, insomnia, and seizures[54]. These medications inhibit episodic memory, which allows people to remember experiences that they have personally witnessed. There are three primary forms of memory viz., sensory memory, short-term memory, and long-term memory. Amongst which it is the short-term memory which seems to sustain the most damage from FNZ[55]. Short-term memory, often referred to as working memory, is a crucial component of cognitive function responsible for temporarily storing and manipulating information.

Memory and GABA_A receptors:

Memory consists of three stages: acquisition, consolidation, and retrieval[56]. FNZ interferes namely with the initial stage of memory process which enables it to start the pathway of anterograde amnesia. This in turn leads to activation of GABA-A receptors which facilitate the amnesic effect of FNZ. Any new information that a person wants to learn is not possible if some certain new connections in neurons and memory are not made. Thus, this is also one of the ways that FNZ affects development of any new memory. Apart from these, some modifications in the synapse transmission of hippocampus region have also been documented to trigger amnesic effects of FNZ. This is enabled as the hippocampus region has binding sites for the GABA-A receptors to bind on. Another one of the mechanisms, that FNZ is known to interfere with is the long-term potentiation which is thought to lead to learning and memory processes[55].

Nitric oxide (NO) is a vital signaling molecule which is produced from the amino acid L-arginine by the enzyme nitric oxide synthase (NOS)[54]. NO is particularly important in the nervous system, where it regulates neuronal excitability and synaptic plasticity, which are crucial for learning and memory. Furthermore, NO is thought to contribute to drug tolerance, affecting how the body responds to certain medications over time. There are four isoforms of NOS out of which the neuronal, nNOS is predominantly found in neurons and is involved in neurotransmission[57]. NO is believed to play a key role in LTP, influencing learning and memory processes. In various rodent memory models, it has been discovered that inhibiting NOS behavior impairs cognitive reactions. NO donors, L-arginine and molsidomine may help to counteract these negative effects[58]. The fluctuation in levels of NO in the body are also caused by some neurological disorders such as epilepsy and anxiety. These fluctuations have been linked to impair the process of memory formation. Here, some drugs which are also donors of NO, such as sodium nitroprusside and molsidomine can be used to counteract the impairment of cognition[59].

NO helps in production as well as reuptake of many neurotransmitters including even GABA[60, 61]. For instance, the release of GABA in the cerebral cortex, hippocampus, and striatum is positively correlated to great amounts of NO concentration in the CNS[62]. The authors Orzelska et. al., have conducted a research study in animal models comparing the effects of diazepam and flunitrazepam in a novel object recognition (NOR) task. Here two different memory models NOR and mEPM were used. Wherein, the NOR is a behavioral test that is used to model human amnesia in animals. It takes advantage of rodents' natural desire to investigate new items and assesses their ability to remember what they have seen. mEPM, which is a rodent spatial memory model, is another animal model of amnesia. It takes advantage of their inherent aversion to open, elevated spaces. In the mEPM procedure, memory impairments were verified whereas, in the NOR test anterograde amnesic effects were seen. Adding to this a similar study was conducted recently which showed that flunitrazepam enhances memory consolidation in the object recognition task, potentially through modulation of the NO-cGMP pathway[63].

In behavioral studies it has been noticed that sildenafil, a phosphodiesterase (PDE-5) inhibitor and methylene blue, a soluble guanyl cyclase inhibitor, reduces memory damage due to FNZ. Here it showed that memory impairment due



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to FNZ can be reversed by using methylene blue. Many recent behavioral studies have found that the cGMP levels improve learning and memory processes by inhibiting PDE, especially PDE-5[64-66]. It acts as a cognitive enhancer by interfering with transduction of signal in the NO:cGMP pathway. The selective behavior of methylene blue or sildenafil on particular GABA-A receptor subunits may be a reason for the divergent effects of both the drugs. It is worth noting that in this analysis, both sildenafil and methylene blue did not show any significant difference in NOR and mEPM models when given alone; as opposed to when they were administered along with FNZ. Based on the findings, we can deduce that NO-related mechanisms could be involved in FNZ-induced memory failure in rodents and perhaps in humans too.

Endothelial-NO-mediated and endothelium-independent pathways**Direct Vasorelaxant Action:**

The endothelial NO-mediated pathway refers to the production of nitric oxide (NO) by endothelial cells in response to various stimuli, including shear stress and neurotransmitters. NO, in turn, plays a crucial role in vasodilation and neurotransmission. Endothelium-independent pathways involve the direct effects of drugs on vascular smooth muscle cells, bypassing the need for endothelial NO production. These pathways can be activated by exogenous NO donors or by drugs that directly activate guanylate cyclase, leading to the production of cyclic guanosine monophosphate (cGMP) and subsequent smooth muscle relaxation[67]. It can be understood with the help of Fig. 2. Flunitrazepam's effects on endothelial cells may involve oxidative stress[68]. Flunitrazepam has been implicated in endothelial dysfunction, a condition characterized by impaired NO production and vascular dysfunction. Research has shown that flunitrazepam can modulate NO production in rat cavernous tissue by down-regulating nitric oxide synthase (NOS) and phosphodiesterase type 5 (PDE5) expressions, leading to increased NO levels and enhanced smooth muscle relaxation[47]. The involvement has been clearly noticed in all the three pathways (Fig 3).

According to a study flunitrazepam when given orally at night for four weeks, resulted in a substantial reduction in nighttime blood pressure in healthy volunteers aged 21 to 30[69]. It was observed that in healthy volunteers that there were reduced levels of systolic as well as diastolic blood pressure[70]. In a few studies, it has been observed that BDZs such as diazepam[71], flunitrazepam[72], flurazepam[71], midazolam[74] and tetrazepam[73] show a direct action on arteries in animal models and cause vasodilation. Studies have also suggested that chronic use of flunitrazepam may contribute to endothelial dysfunction and cardiovascular risk[75].

A study by Zhang et al., investigated whether NO from vascular endothelium is involved in the relaxation induced by four benzodiazepines all of which are known for their vascular relaxing effects. The study found that the arterial relaxation induced by these drugs, as well as by L-NAME (N ω -Nitro-L-arginine methyl ester), a NO synthase inhibitor, was significantly inhibited after endothelium denudation, suggesting the involvement of endothelial NO in the vasorelaxant effects of these drugs[76]. Other study reports found that treatment with BDZs increased NO production in endothelial cells, suggesting a potential mechanism for the vascular relaxing effects of these drugs[77]. Hence, if this vasodilatory action of FNZ is interrupted then the side effects, such as dizziness and palpitation can also be inhibited.

CONCLUSION

Despite its beneficial applications, FNZ remains predominantly utilized for its adverse effects. NO, the key bioregulatory molecule, contributes to all the main pathways through which flunitrazepam induces its primary adverse effects. NO is particularly important in the nervous system, where it regulates neuronal excitability and synaptic plasticity, which are crucial for learning and memory. Flunitrazepam's effects on the L-arginine:NO:cGMP pathway contribute to its sedative-hypnotic and anxiolytic effects, by modulating neurotransmission and synaptic plasticity. The studies included in this review have demonstrated that flunitrazepam can alter NO production and cGMP levels in the brain. In behavioral studies it has been noticed that sildenafil and methylene blue reduce memory damage due to FNZ and thus, it can be used to reverse the memory impairment due to FNZ. Also, it has been





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observed in the endothelial pathways that production of increased levels of NO due to modulation cause enhanced smooth muscle relaxation which eventually lead to drowsiness. Hence, all the findings from different studies give us an understandable perspective towards the workings of FNZ and its adverse effects. In conclusion, we would like to suggest that further study is required to find a possible way to interrupt the interaction of FNZ with the pathways of NO combined with L-arginine, cGMP and endothelial tissues which can help minimize or even alter the adverse effects of FNZ.

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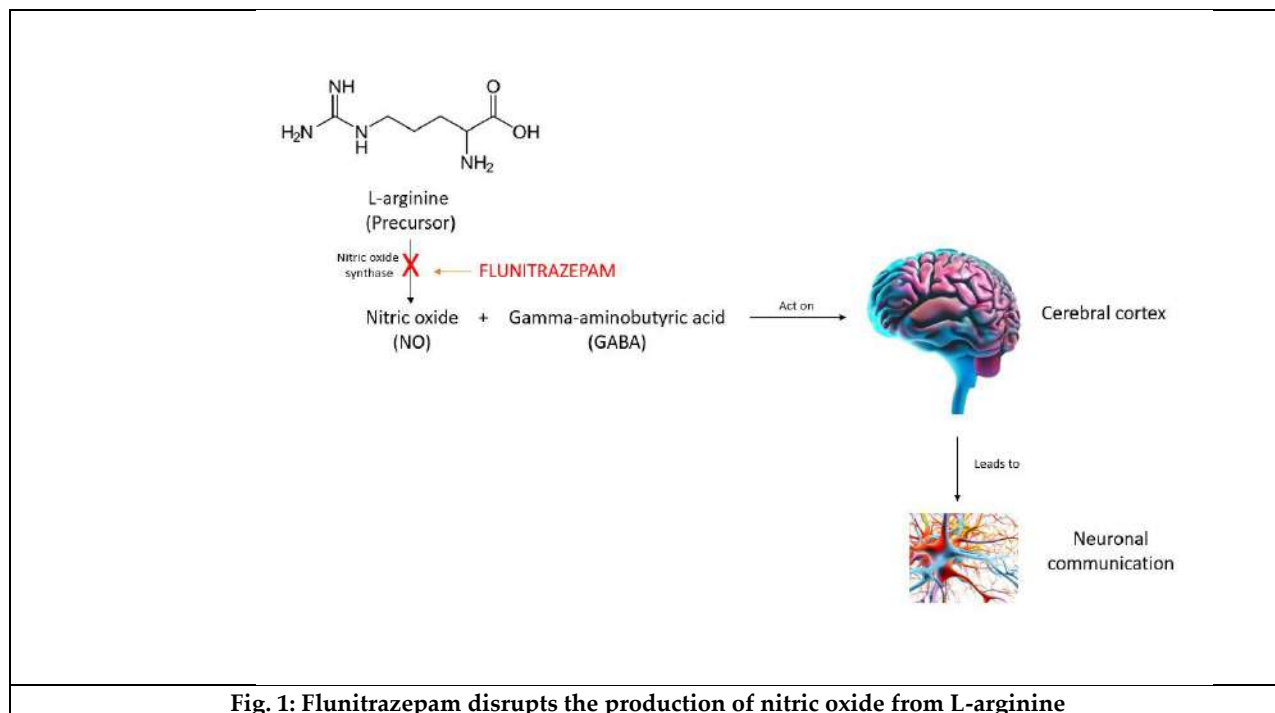


Fig. 1: Flunitrazepam disrupts the production of nitric oxide from L-arginine





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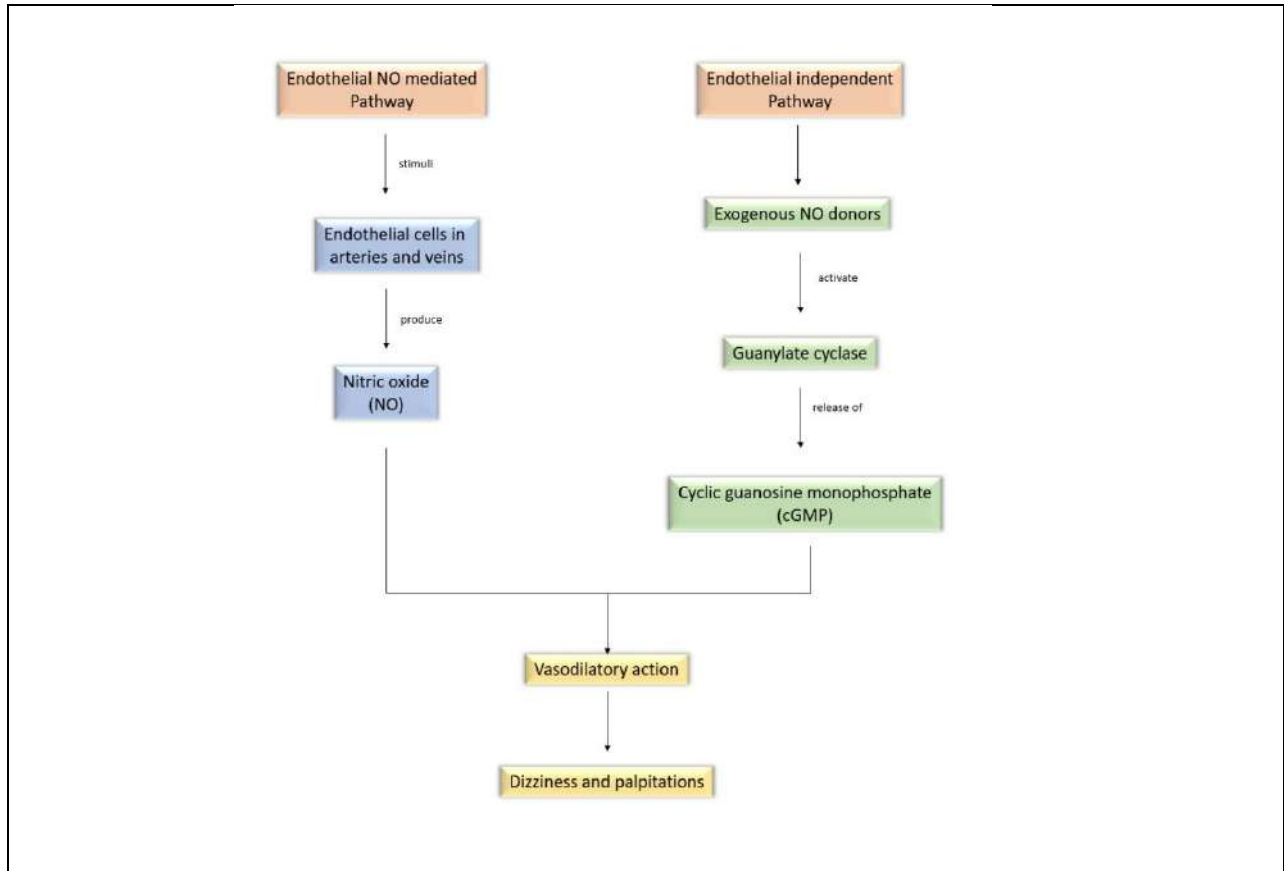


Fig. 2: Mechanisms of endothelial NO mediated and endothelial independent pathways

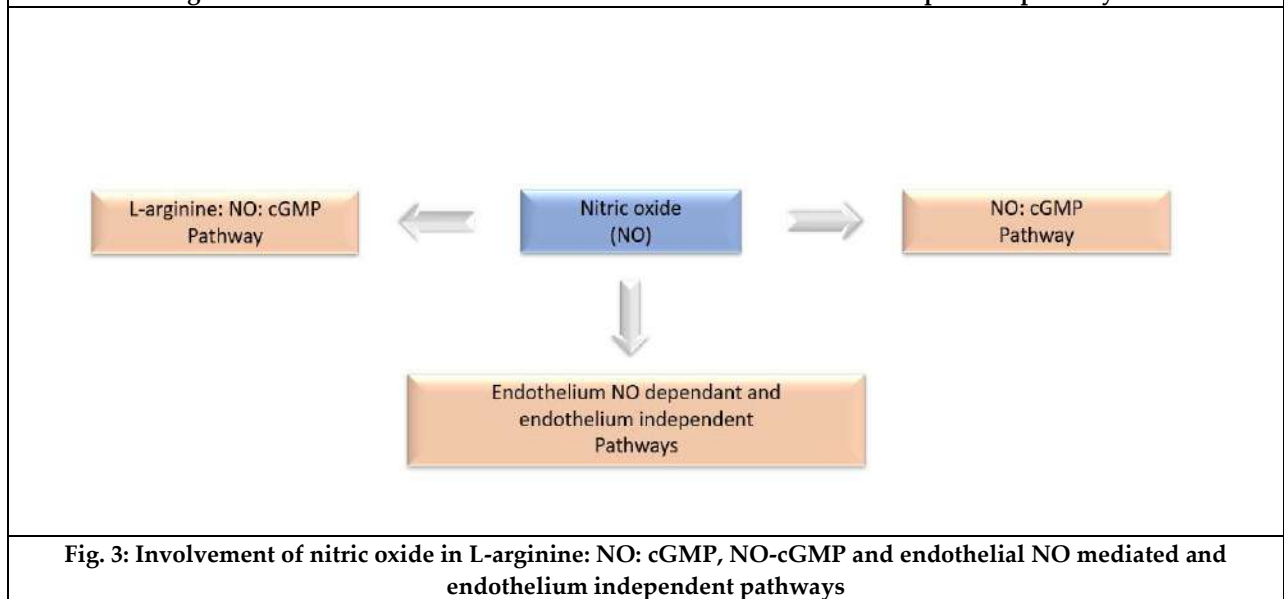


Fig. 3: Involvement of nitric oxide in L-arginine: NO: cGMP, NO-cGMP and endothelial NO mediated and endothelium independent pathways





A Model for Efficient Media Dependent Resource Utilization Techniques for Massive Data Learning using Clustering in Grid Computing

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ABSTRACT

The primary goal of this proposed work is to enhance the synchronization of media parameters by optimizing grid process running time. The work is divided into four main tasks: estimating grid process running time, optimizing loading harmonization, clustering media parameters based on instructional and media factors, and improving load balancing. The aim is to ensure that a shared media object can be efficiently delivered to a large number of users simultaneously through effective harmonization and clustering. This approach is designed to reduce grid process running time for the same media object, even with a high number of users accessing it at the same time. The clustering in this study is categorized into Instructional Parameters and Media Parameters, with a primary focus on media parameters, particularly in the context of massive clusters. The subsequent category involves load harmonization based on Poisson distribution, where the average and actual numbers of successes from experiments are analyzed. This approach aims to understand and optimize massive clusters within learning grids.

Keywords: harmonization, e-content, grid, load balancing.

INTRODUCTION

Information Technology has advanced significantly over the past twenty five years, leading to a gradual rise in the use of online courses. These courses are typically divided into instructional and media categories. When a single file (a shareable object) is accessed by many users simultaneously, the loading time for that file can increase. To address

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this issue, the proposed work focuses on reducing loading times through harmonization and clustering techniques[1]. The proposed work is shown in the following Figure 1. Initially when the user searches the appropriate documents for learning through Electronic-content developments.

PROPOSED WORK

E-content is becoming a standard due to its flexibility in terms of time, location, and pace of learning. It encompasses all types of content created and delivered through various electronic media and is available across a wide range of subjects and educational levels. E-content caters to diverse learners with different needs, backgrounds, and levels of experience and skill. It can be easily and quickly shared among a vast number of users globally. Both teachers and students benefit from the use of simple and advanced e-content, which offers significant advantages to educational institutions by making their programs accessible in various settings such as fields, homes, and community learning centers. This has profound implications for open and distance learning institutions.

E-content development has seen substantial growth over recent decades, leading to a surge in online learners and the rise of platforms like MOOCs (Massive Open Online Courses), NPTEL (National Programme on Technology Enhanced Learning) and Coursera, which offer unrestricted participation and open access via the internet. Besides traditional materials such as recorded lectures and problem sets, many courses on these platforms now incorporate interactive elements like user forums for community interaction and instant feedback on quizzes to enhance the learning experience. NPTEL, introduced in 2006 and gaining popularity in 2012, initially focused on open-access principles, including open licensing to encourage the reuse of resources, though some courses have since adopted closed licenses while maintaining free access. Similarly, Coursera, launched in 2012, provides a wide range of courses from top universities and institutions, often featuring a mix of open and proprietary content[4]. Today, online courses from platforms like MOOC's, NPTEL and Coursera are increasingly utilized by schools, colleges, companies, and individuals seeking certifications. A major challenge for these platforms is efficiently distributing content to a large number of users, which involves managing one-to-many or many-to-many interactions. To address this, the concept of shareable common objects has been introduced.

Shareable Common Object (SCO)

A Shareable Content Object (SCO) represents the fundamental unit of learning within the SCORM framework. Depending on the context, it may be called a module, chapter, or page. The defining feature of an SCO is its diverse range in size and content. As per the SCORM (Shareable Content Object Reference Model) standard, an SCO should be the smallest unit of content that is both reusable and self-contained[3]. In a Learning Management System (LMS), an SCO is individually listed in the table of contents and tracked separately from other content. It includes its own marker, score, and completion status, as illustrated in Figure 2. A significant challenge with Shareable Content Objects is managing the delivery of content from multiple servers to a large number of clients. This issue can be addressed through Load Balancing. Load Balancing is a method used to distribute tasks or requests across several computers. For example, if many users are seeking e-content on C-Programming, specifically about while loops, Load Balancing ensures that the content is provided to all users promptly. Regardless of whether there are tens, hundreds, thousands, or even millions of users, optimizing Load Balancing for Shareable Content Objects helps manage the distribution effectively. The figures illustrating Load Balance's are shown below.

Load Balancing can be enhanced through the use of clustering. In the realm of e-content development, clustering is a key approach. A cluster typically consists of multiple servers running the same application. This setup serves two main purposes: to distribute the load across different servers and to provide redundancy and fail-over mechanisms[2]. Within a cluster, tasks are evenly distributed among the servers. This method is most effective when all servers have the same capabilities and each task requires a similar amount of effort. The sample e-content are classified into four ways as shown in Figure 4. First it includes normal languages used in the real world environment; second, e-content is related to the mechanical studies; Third, e-content is related to the business management people and Fourth, e-content are categorized into programming languages used in the computer programming





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By analyzing the Shareable Content Object file and its memory usage, you can determine its performance in a grid processing environment using GridSim 5.0. Grid computing technology is increasingly used to deploy e-learning content over the internet, as e-learning environments often require substantial computing resources to support a large number of simultaneous users. Consequently, both software and hardware need to be frequently updated or upgraded to accommodate these demands[1]. Large learning grid could be a machine cooperative setting for effectively endeavor massive pools of e-learners of the online that is turning into vogue the. One among the basic problem in such grid environments is job programming, that is required for achieving higher performance As grid setting is mostly suburbanized and it consists of heterogeneous systems, economical programming technique would be noticeably required for sound acceptable resources for relevant e-content; say massive or little or the e-content.

Load harmonization based on grid process running time has been applied to media parameters in large-scale learning grids. For massive open online courses (MOOCs), load harmonization for media parameters is estimated using a Poisson distribution. The proposed work is categorized into four areas: grid process running time, harmonization, clustering, and load balancing. The size and memory usage of each Shareable Content Object can be determined through Java programming. When many users access the same Shareable Content Object, these metrics can be calculated for each experimental trial using the Poisson distribution.[3]

Find out the chances of occurrence of a number of events in some given time interval or given space conditionally that the value of the average number of occurrence of the event is known. In a dynamic learning grid environment with a vast amount of knowledge and numerous users, virtual warehousing can be utilized for storing and retrieving data. Virtual warehousing, a crucial technology in e-commerce, offers flexibility in managing large datasets. One of its main benefits is cost reduction, as it eliminates the need to structure individual data sets for many concurrent users, allowing multiple learners to access a single data source. Additionally, using independent and Poisson probabilities to minimize redundant computations within learning grid clusters can conserve computational resources for thousands of simultaneous users.

EXPERIMENT AND RESULT

The following shows the instructional objects based on the file size and the memory utilization and the processing times are calculated using GridSim 5.0. File size and Memory are measured in terms of Kilo Bytes. Grid processing time is measured in terms of milliseconds.

- The file size of the 'definable' instruction object in storage is 188KB; and its size in memory is 186.6KB; processing time by the GridSim 5.0 would be around 2300 ms (excluding user retention time).
- The file size of the 'demonstrable' instruction object in storage is 654KB; and its size in memory is 651KB; processing time by the GridSim 5.0 would be around 14300 ms.
- The file size of the 'solvable' instruction object in storage is 362KB; and its size in memory is 660.7KB; processing time by the GridSim 5.0 is around 8600 ms.
- The file size of 'perceivable' instruction object in storage is 160KB; and its size in memory is 158.8KB; processing time by the GridSim 5.0 would be around 1800 ms.
- The file size of the same content integrated into a single document is about 1346KB; size the same in memory is 1340KB; processing time by the GridSim 5.0 would be around 28350 ms (excluding user retention time).
- With authorized research support [Kaladevi 2013], the average computational ratio of Definable , Demonstrable , Solvable , Perceivable has been empirically worked out to be about: 1.00 , 4.00,,3.00 , 0.75 (i.e 11.5% : 46% : 34.5% : 8%), which is more or less matching with size and computational time.
- In a similar empirical study on media categories with authorized research support [Jagadeesan, B 2014], the average empirical computational ratio of Textual: Graphical: Animation is about 1.00 , 1.10 , 1.30 (i.e 28% : 33% : 39%) respectively.





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The above Table 1 shows the summarized the specification, trials and range for the samples and inputs for the proposed experimental setup. Tasks of massive users take 10, 50, 100, 200 and 400 experimental trials of tasks. Clusters or Resources for creation of task for massive

users takes trial ranges from 1000 to 10000. Massive clusters that would be grouped into resources that can be varied different ranges and will be decided through first experiments. Parameters for selection of clusters for experimental trials are trust based performance based and to remove the redundancy.

The above table 2 shows the grid processing time of Instructional parameter. For Each category of instructional parameters the experimental trials of tasks are taken from 1000 to 10000. Instructional Parameters are Definable, Demonstrable, Solvable and Perceivable.

Definable cluster or task ratio is 4,

Demonstrable cluster or task ratio is 8,

Solvable cluster or task ratio is 5

Perceivable cluster or task ratio is 7

Based on the cluster or task ratio and experimental trials of task average grid processing time are calculated by using GridSim 5.0

Above table 3 shows the grid processing time for Media parameter. For Each category of media parameters the experimental trials of tasks are taken from 1000 to 10000. Media parameters are Textual, Graphics, and Animations.

Textual cluster or task ratio is 8,

Graphics cluster or task ratio is 9,

Animations cluster or task ratio is 11

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Table 1. Experimental Setup for Grid Resources

Specification	Trials & range
Tasks for massive users (Experiment 1).	10, 50, 100, 200 and 400
Clusters (resources) requested for creation of tasks for massive users (Experiment 2).	1000 – 10000 in steps of 100
Massive clusters that would be grouped into resources.	Varies and will be decided through first experiments
Parameters for selection of clusters (Experiment 1)	Trust, performance, redundancy removal





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Table 2 Grid Processing Time for Instructional Parameter

TRIALS	DEFINABLE (CLUSTER 4)	DEMONSTRABLE (CLUSTER 8)	SOLVABLE (CLUSTER 5)	PERCEIVABLE (CLUSTER 7)
1000	2858	15865	8740	1867
2000	2846	15020	8904	1845
3000	2818	16980	8965	1898
4000	2840	17030	9083	1904
5000	2878	16820	9154	2065
6000	2903	16092	9258	2037
7000	2840	17896	9474	2176
8000	2880	17670	9787	2297
9000	2895	18005	9937	2303
10000	2816	18875	9956	2455

Table 3. Grid Processing Time For Media Parameter

TRIALS	TEXTUAL (CLUSTER 8)	GRAPHICAL (CLUSTER 9)	ANIMATION (CLUSTER 11)
1000	5002	5980	6379
2000	5976	6258	6904
3000	5620	6984	7408
4000	6278	7158	7923
5000	6128	8003	8509
6000	6503	8823	8165
7000	6400	9043	8964
8000	7078	8978	9472
9000	7587	9539	9946
10000	8198	9912	10027

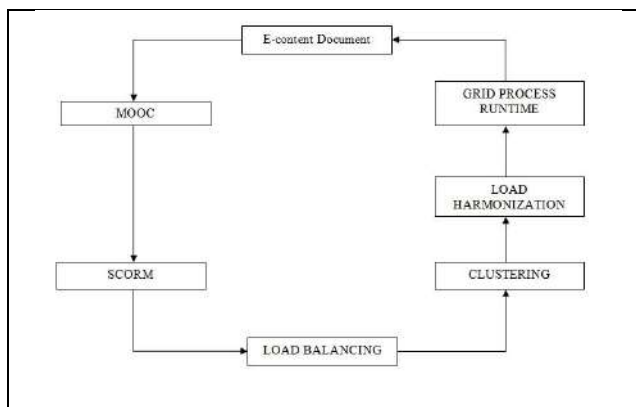


Figure 1 Proposed Work

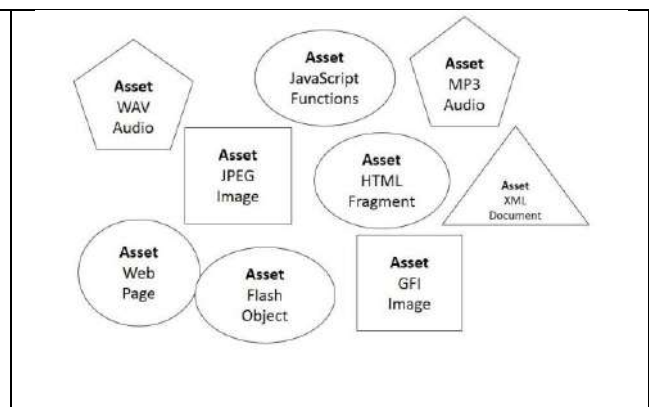


Figure 2 Shareable Content Object Reference Model.





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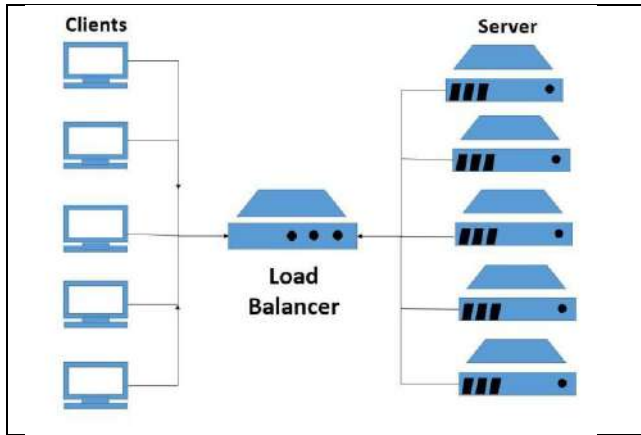


Figure 3. Load Balancing

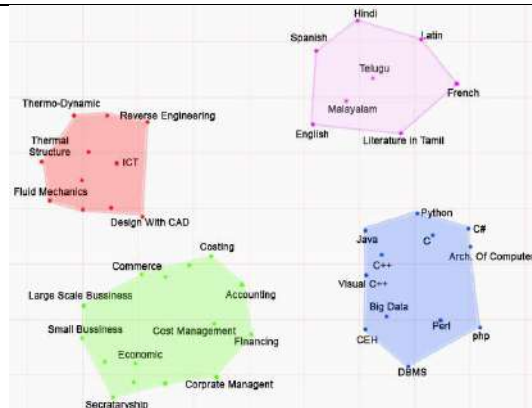


Figure 4 : Sample Categorization of E-Content





Machine Learning Algorithms for Predicting Pregnancy Risks : a New Frontier

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ABSTRACT

Pregnancy, a significant life event, poses dangers for both the mother who is carrying the child and the developing fetus. Machine learning (ML) is essential in the medical field, specifically for healthcare diagnosis, assessment, and therapy. Conventional diagnostic methods may encounter difficulties in accurately diagnosing high-risk pregnancies, leading to potential complications and adverse outcomes for both the mother and the fetus. Recent advancements in machine learning (ML) algorithms have demonstrated remarkable efficacy in detecting and predicting high-risk pregnancies by analyzing a range of clinical, physiological, and behavioral data. This review study describes the supervised and unsupervised learning approaches used to identify high-risk pregnancies. Machine learning algorithms offer benefits in identifying high-risk pregnancies. Some of the advantages include prompt action, enhanced precision, and tailored treatment approaches. Implementing machine learning can lower the expenses associated with costly medical interventions.

Keywords : Machine Learning; fetus; high-risk pregnancies; Algorithms;





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INTRODUCTION

Pregnancy, a significant life event, poses dangers for both the mother who is carrying the child and the developing fetus. Machine learning (ML) is essential in the medical field, specifically for healthcare diagnosis, assessment, and therapy. Conventional diagnostic methods may encounter difficulties in accurately diagnosing high-risk pregnancies, leading to potential complications and adverse outcomes for both the mother and the fetus. Recent advancements in machine learning (ML) algorithms have demonstrated remarkable efficacy in detecting and predicting high-risk pregnancies by analyzing a range of clinical, physiological, and behavioral data. This review study describes the supervised and unsupervised learning approaches used to identify high-risk pregnancies. Machine learning algorithms offer benefits in identifying high-risk pregnancies. Some of the advantages include prompt action, enhanced precision, and tailored treatment approaches. Implementing machine learning can lower the expenses associated with costly medical interventions [1]. While technological developments in obstetrics and gynecology have been considerable, it is crucial to realize that not all dangers can be entirely removed [2].

According to World Health Organization in 2020, around 800 women died during pregnancy due to different risk factors involved during pregnancy. Every day in 2020, about 800 women died from pregnancy and childbirth-related causes that may have been avoided. In 2020, a mother's death apparently happened every two minutes. Between 2000 and 2020, the global maternal mortality ratio (the number of pregnancy - related deaths per 100,000 live births) lowered by approximately 34% [3]. Numerous machine learning methods and technology is used for pregnancy related diseases. Stress detection of working lady during pregnancy by using neural network .In a recent studies a semi-supervised machine learning to predict pregnancy related risks in Philippines [4]. A supervised learning was used to detect pregnancy risk due to hypertension, in this study, graph-based SSL was used to simultaneously incorporate labeled and unlabeled data in order to predict pregnancy-related HTN [5]. In 2022, a research was done on creation of a cerebral infarction (CI) threat prediction using machine learning techniques to mine huge data from common test results [6]. Preeclampsia is an anomaly of pregnancy that appears after 20 weeks of pregnancy and is characterized by proteinuria and hypertension and research as done on algorithms for detection of these risks using deep learning and neural network [7].

The study by [8] examined the effectiveness of three classification algorithms: the logistic regression classifier, rule-based classifier, and RF classifier [9]. They made use of the PhysioNet [10] Term-Preterm EHG database. With a sensitivity of 97%, specificity of 86% AUROC of 94%, a mean square error rate of 14%, the RF classifier performed the best. There was no reported accuracy rate, false positive rate (FPR), or false negative rate (FNR). Another study shows the potential of utilizing machine learning techniques to forecast the lifetime of preterm children based on clinical & demographic factors. The creation of the PISA predictor may enable healthcare professionals to make better choices regarding the preterm newborns they treat and care for, thereby improving their patients' outcomes [11]. Another study used graph-based semi-supervised learning to create a prediction model for pregnancy-related hypertension. In comparison to the most recent clinical recommendations and a predictive biomarker, the model had a greater predictive accuracy. The best average model parameters was demonstrated by the top 11 variables chosen by feature selection, with a mean AUC of 0.89 with training dataset & 0.81 in the test set. Using common clinical characteristics, the suggested model may successfully predict the onset of hypertension associated in pregnancy in the early stages of pregnancy [12].

In an effort to enhance prenatal care in remote areas of low- and middle-income nations, the paper suggests adopting portable ultrasound devices, blood and urine testing to identify high-risk pregnancies and send them. In order to care for 10,108 pregnant women over the course of two years and three months, the Healthy Prenatal project, a case study, trained migratory nurses and provided them with mobile ultrasound systems and tests. The findings demonstrated that nursing personnel may quickly identify and refer the majority of obstetric concerns, helping to lower maternal mortality, with the right tools, training, and supervision. The study emphasizes the strategy's potential to enhance maternity care in rural low- and middle-income nations [13].



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Another study with an objective to examine the outcomes of both Deep Learning & Neural Network models in order to predict the risk of preeclampsia in pregnant women. A particle swarm optimization (PSO) algorithm was used to minimize the number of features from 17 to 9, using the study's 1077 patient data as input. In comparison to the original data, the results indicated that Deep Learning executed more quickly and had an accuracy of 95.12% while using the raw data and 95.68% when using the smaller dataset. The variety of attributes could be greatly reduced with PSO while preserving and enhancing precision. Deep Learning has been demonstrated that it's an effective edge framework that does not need sophisticated systems or in-depth data analysis [7]. The study was conducted in rural India, where the prevalence of preterm delivery is high and there are little resources available to support pregnant women and new babies. The authors want to create a model that could forecast the likelihood of preterm birth and help with intervention decision-making. Several machine learning models, such as logistic regression, decision trees and support vector machines, were developed and tested by the authors. Accuracy, specificity, and sensitivity are used to evaluate the classifiers' performance. Finally, compared to the other learning classifiers utilized in this study, the SVM classifier provides an accuracy of 90.9%[14].

A systematic review was conducted to evaluate the entire artificial intelligence model in pregnancy related risks and labor after conducting a thorough search of numerous databases. A total of nine categories of AI applications were discovered, including pregnancy risk evaluation, prenatal diagnosis, pregnant hypertensive problems, stillbirth, foetal growth, premature deliveries, delivery route, and others. The best artificial intelligence application for evaluating medical issues, in accordance with this systematic review, is ANN approaches. It has been determined that ANN approaches typically have an accuracy of 80–90%. The authors have included papers that apply AI-based algorithms for forecasting adverse affects during pregnancy. The notion that this publication offers a critical examination of the many research is one of its advantages [15]. A random forest regression technique was used in the study discussed in the content to create a prediction models for GDM in pregnant women. Around 4800 pregnant women's data were gathered, and the researchers used a literature review, expert discussion, and 67 indications of GDM to identify them. According to the study, the generated model performed well, with overall predictive accuracy for the F1 data set of 93.10% as well as an AUC of 0.66 and overall predictive accuracy for the F2 data set of 88.70% and 0.87 respectively [16]. The literature on the application of affective computing and artificial intelligence to pregnancy health was examined in this scoping review, which covered the years 2008 through 2020. Although the study revealed that emotional well-being can be a substantial risk factor throughout pregnancy, there is currently a dearth of research on automated emotion analysis. According to the review, future studies should concentrate on creating AI & affective computing-based products to improve the health and wellbeing of expectant mothers [17]. Another study was designed in order to reduce the danger of multiple pregnancies and maintain the best pregnancy odds, the goal of this study was to build artificial intelligence algorithms that could forecast the pregnancy result and repeated pregnancy risk after IVF-ET. Among the six machine learning techniques employed for model development, XGBoost performed the best. The dataset includes 1507 fresh embryo transfer cycles. The accuracy, sensitivity, specificity, and AUC values for the pregnant women prediction model were 0.716, 0.711, 0.719, and 0.787, respectively. With an accuracy of 0.711, specificity of 0.740, sensitivity of 0.649 and AUC of 0.732, the multiple pregnancy prediction method performed well. According to the study, using AI models to reduce the probability of multiple pregnancies following IVF-ET is a promising strategy [18].

DISCUSSION

A number of studies have revealed that the use of Machine learning can reduce high-risk during pregnancy. A decision tree method was employed in one study to predict preterm birth using information on the mother's demographics, previous health history, and foetal growth. In terms of predicting preterm birth, the algorithm has a sensitivity of 79.4% and a specificity of 81.6% [19]. Another study was conducted considering maternal health and demographic information using a random forest algorithm to forecast gestational diabetes. The system successfully predicted gestational diabetes with an area under the curve (AUC) of 0.77 [20].





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Deep learning-based neural networks have been utilized to solve a variety of challenges in several disciplines in recent years. Deep neural networks learn complicated relationships between variables using layered design. A well precise decision support system is required to obtain accurate outcomes from the diagnosis procedure while minimizing costs. Classification of diseases based on multiple characteristics is a difficult work for human professionals, but AI can help to detect and handle such risks. Several AI techniques are currently being applied in the field of medicine to accurately diagnose illnesses. AI is a component of computer science that allows computers to become more intelligent [21].

Initially, rule-based decision-making was the main component of AI techniques that was commonly utilized in healthcare. Because they can perfectly mimic the physicians' own decision-making process, AI solutions that use rule-based decision-making fit in with the clinical setting organically. MYCIN was one of the initial rule-based decision-making algorithms. MYCIN was created in 1974 to forecast the best course of treatment for certain bacterial illnesses. It was created as "expert system" that would use a sequence of if-then statements to direct therapists towards the best course of action. It would take another 20 years for these "expert" rule-based systems to be used for the first time, in 1994, when a rule-based predictor of the risk of preterm birth was created. An application of AI known as machine learning (ML) permits learning without explicit programming. An artificial neural network (ANN), a common ML technique, is created to approximate how biological neural networks process data. We identified three main areas where applying AI techniques could help us better understand the pharmacological impacts of pregnancy, including: Acquiring significant and trustworthy information from clinical records; establishing efficient animal experiments to test particular ideas; designing decision-support tools that guide decisions [22].

It has been 25 years since the first AI tool for a woman's health issue—preterm birth—was created, and 45 years since the creation of the first AI system with a health focus. Recently, two studies published in the New England Journal of Medicine brought attention to the critical need for novel approaches to study pharmaceutical effects in both pregnant and lactating women [23]. 90 percent of pregnant women take a pharmacologic at some point during their pregnancy, according to Eke et al. and Mitchell et al., and between 70 and 80 percent of pregnant women gain a pharmacologic during the first trimester of their pregnancies, which is the most dangerous due to congenital anomalies and unfavorable foetal outcomes [24]. We have seen previous work done on utilizing different machine learning algorithms in pregnancy related risk analysis. We can differentiate these models on the bases of their sensitivity, accuracy and precision. We can use these factors to check which model is best for risk detection.

Types of machine learning

We broadly classify machine learning into three categories²⁵ and in some papers they are classified in four categories [26].

- **Supervised learning:** This kind of machine learning entails using labeled data to train the algorithm. It makes use of a dataset where every observation has a corresponding label or result. Then the model uses this information to make predictions on unseen data. Image recognition, speech recognition, and home price forecasting utilizing factors like location, bedroom count, and square footage are all common uses for supervised learning [27].
- **Unsupervised Learning:** The algorithm is trained with unlabeled data in this sort of machine learning. It looks for patterns or clusters in the dataset without knowing what the results should be in advance. Unsupervised learning frequently uses clustering, in which the algorithm groups together data points with similar characteristics [27].
- **Semi-Supervised Learning:** Unsupervised and supervised learning are combined in semi-supervised learning, a kind of machine learning. It entails putting the algorithm through training on a dataset containing both labeled and unlabeled data. While making predictions, the algorithm applies the patterns it has learned from the labeled data to the unlabeled data. When labeled data is expensive or challenging to collect, semi-supervised learning is advantageous [28].
- **Reinforcement Learning:** With this kind of machine learning, a decision-making algorithm is trained to take into account mistakes and previous decisions [29]. By acting and getting rewards or penalties for such behaviors, the





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algorithm operates from its surroundings. Throughout time, the aim is to increase the benefits and decrease the penalties. Robotics, video games, and autonomous cars frequently use reinforcement learning [28].

Analysis of machine learning algorithms

From different researches papers we observed different parameters that were mostly used for the analysis of machine learning algorithms. Following are some of the parameters

Accuracy

One of the most often applied evaluation measures in machine learning is accuracy. It calculates the proportion of accurate predictions of a model on a specific dataset makes. Accuracy is specifically determined by the proportion of the number of correct predictions to the sum of all the predictions [30].

It can be calculated by the formula: $AC = \frac{TP + TN}{TP + TN + FP + FN}$

Precision

The proportion of true positives, or instances of a particular class that are properly identified, among all positive predictions that are made by a model, is measured by precision, an extensively used evaluation metric in machine learning [31]. It can be calculated by the formula: $P = \frac{TP}{TP + FP}$

Recall

Recall is a metric that is used to measure how well a model performs at correctly identifying every relevant instance in a dataset. Out of all positive cases in the dataset, it calculates the proportion of real positive instances that the model properly detected [32].

It can be calculated by the formula: $P = \frac{TP}{TP + FN}$

1. F represents the equilibrium in between P and R values. Since we care more about labour data in our results, a higher F value indicates a stronger classifier.

It can be calculated by the formula: $F = \frac{2 * P * R}{P + R}$

2. F1 score

F1 score is a parameter that is frequently used in data analysis along with machine learning to assess how well a classification algorithm is performing. It refers to the harmonic mean of recall and precision, two additional often employed measures. A higher score on the F1 scale, which spans from 0 - 1, indicates superior performance. Using different algorithms for machine learning in pregnancy-related risk analysis has been the focus of past research. These models can be distinguished based on their sensitivity, accuracy, and precision. These elements enable us to assess which model is the most effective at identifying risks.

FINDINGS

Algorithms used in pregnancy related risk

The degree to which a person can accurately predict the result of a model that has been well-accepted by the clinical team is referred to as the applicability of ML models. From the previous papers I came across, the support vector machine, neural networks [33], decision tree, Naive Bayes, logistic regression, deep learning and random forest [34]. ML techniques were most frequently employed to predict pregnancy related problems. In which it was noticed that the highest AUC value was 0.95 for SVM [2].

Model validation methods

Validation procedures are approaches used in machine learning (ML) to assess how well a trained model performs on incoming, unknown data. These techniques measure a model's ability to generalize and generate precise predictions on data that it has never seen before. Three widely used techniques for validating Machine learning algorithms are cross-validation, testing, and training.





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- **Training:** When a model is trained, its parameters are adjusted to reduce error on a particular collection of data known as the training set. Usually, an optimization algorithm like gradient descent is used for this.
- **Testing:** Testing is the process of assessing the model's performance using a unique data that it has never seen before. The testing data is used to calculate the model's generalization error, or how well it can predict outcomes using brand-new, untested data.
- **Cross validation:** By dividing the given data into numerous subsets, or "folds," cross-validation is a method for assessing the efficacy of a model. A subset of the data is used to train the model, while the remaining subset is used to test it. Several subsets are employed for training and validation during the course of this process's repetition. To estimate the model's performance, the results are averaged.

Predictive aspects

Studies outline the key aspects of pregnant women that may be important in predicting risk. High-ranking factors for the prediction of premature births include the mother's age, the presence of chronic arterial hypertension, gestational diabetes, Preeclampsia [35], heart disease [36], underlying illnesses, gestational hypertension disorders, Fetal growth restriction (FGR) and the father's nationality. It is also crucial to distinguish between provider-initiated spontaneous preterm births and unplanned preterm births [22].

Pre-labor rupture, placenta praevia, and an unspecified antepartum haemorrhage were among the obstetric problems. Preeclampsia, rupture of membranes, threatened miscarriage, preterm birth, infection of the urinary tract, gestational hypertension, and gestational diabetes are some conditions that may occur [37].

Generalized methodology

Machine learning algorithms use technique to evaluate large datasets in order to identify patterns that may be used to build a model that can be used in future for prediction. In the realm of perinatal care, these algorithms can be trained on enormous quantities of data relating to prenatal care, foetal development, and neonatal outcomes to detect potential risks and forecast future concerns. Methodology was divided into six sequentially steps

1. Data gathering and preprocessing: Gather information that is pertinent to your work and prepare it for the model by cleaning, converting, and normalizing it.
2. Model selection: Based on the type of information, the quantity of data, and the difficulty of the task, selects a suitable machine learning algorithm.
3. Model training: Apply the chosen algorithm to the preprocessed data to train the model.
4. Model evaluation: Measure the trained model's accuracy, precision, recall, and some other metrics by applying it to a different dataset (the test set). Metrics including accuracy, precision, recall, F1 score, and area under the receiver operating characteristic (AUC) curve will be used to assess the model's performance.
5. Model tuning is the process of modifying the model's hyperparameters and parameters to enhance performance.

CONCLUSION

We can conclude that machine learning algorithms are used to identify high-risk pregnancies based on this review paper. The analysis and evaluation of several research and methodologies are utilized in the risk factors involved in pregnancy and provided a process that comprises data gathering, risk analysis, data splitting, developing a deep learning-based model, and prediction made by this model. Overall, the outcomes for maternal and foetal health may be improved by the adoption of algorithms based on machine learning for high-risk pregnancy diagnosis. Yet, it is crucial to make sure that the data is gathered and used ethically, and that the algorithms are accurate, objective, and understandable. In order to advance this subject and guarantee its safe and efficient application, more study and cooperation between physicians, data scientists, and ethicists are imperative. There are still research gaps in need of being filled despite the substantial breakthroughs in using algorithms for machine learning to forecast pregnancy-related hazards. To verify that the methods are generally applicable across diverse populations, for instance, larger datasets including a range of population groupings and demographic data are required. Also, adding additional pertinent parameters, such social and environmental ones, could increase the predictive models' precision. To fill up





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the gaps in the existing data and create more precise and generally applicable models for predicting hazards associated with pregnancy, more study is required.

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Table 1. Classification of potential risk factors in pregnancy

Current health conditions	Hypertensive disorders, polycystic ovary syndrome, diabetes, kidney disease, autoimmune diseases, thyroid disease, infertility, obesity, HIV/AIDS
Lifestyle factors	Use of alcohol, tobacco and illegal drugs
Pregnancy conditions	Multiple pregnancy, gestational diabetes, preeclampsia and eclampsia
Age	Adolescent pregnancies, first pregnancy after the age of 35

Table 2. Types of machine learning

MACHINE LEARNING			
Supervised learning	Unsupervised learning	Semi -supervised - learning	Reinforcement learning
1. Classification	1. Clustering	1. Classification	1. Positive
2. Regression	2. Association	2. Clustering	2. Negative

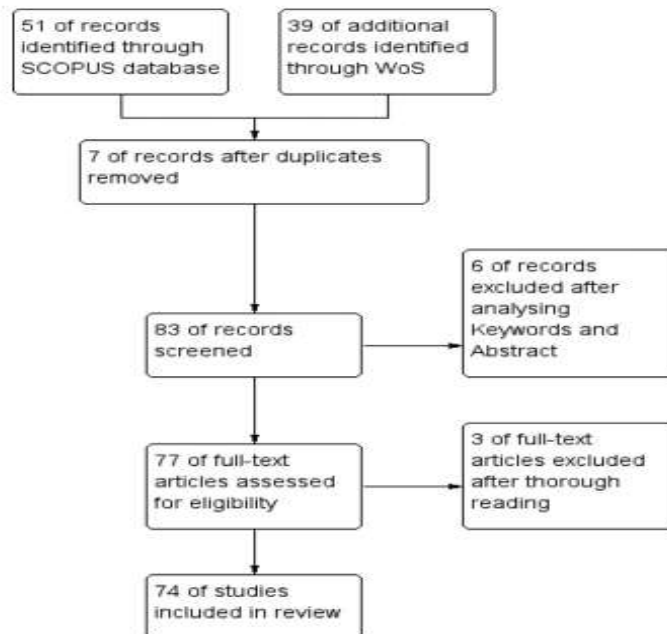


Fig.1 Flow Chart





***In Vitro* Anti-Arthritic Activity of *Piper betel* Flower Extract along with Antioxidant Activity and its *In silico* Molecular Docking Study**

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ABSTRACT

Rheumatoid Arthritis is a chronic, inflammatory, and systemic autoimmune disease, it affects elders worldwide. Herbal medicines have been used for the treatment of various ailments from ancient times. Betelvine (*Piper betle*L.) leaves have long been used in Asian countries as a medicine to relieve pain and some metabolic diseases. The present study of methanolic extract of phytochemical analysis confirms the presence of alkaloids, tannins, terpenoids, saponins, steroids, total flavonoids and total phenols. The long-term condition known as rheumatoid arthritis is marked by joint inflammation that progresses to cause bone loss. According to its important qualities such as antioxidant, anticancer, and anti-allergic, extracts from the *Piperbetel* plant have been used for centuries to treat a wide range of illnesses. *Piper betel* flower extract's antioxidant properties was investigated in this study, and also molecular docking study. To virtually screen a large number of tiny molecules in an attempt to find possible hits, molecular docking of compounds across different databases is helpful. By including distinct molecular scaffolds into the discovery process, these predictions save expenses and save time. Molecular docking was done by using Capsaicin receptor protein 3J9J and3EUB PDB.

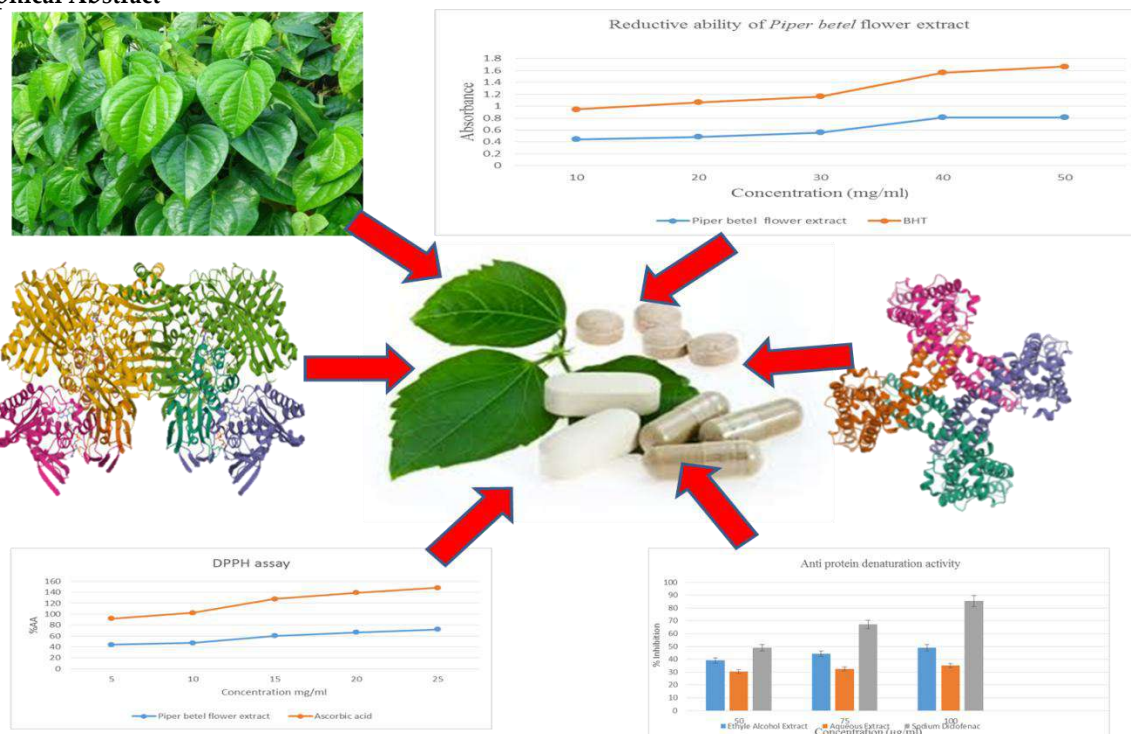
Keywords: Rheumatoid Arthritis, bone, antioxidant, Molecular docking, phytochemical.





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Graphical Abstract



INTRODUCTION

Rheumatoid arthritis (RA) is a systemic autoimmune disease that is persistent and causes degeneration of the joints and bones [1]. Pain, edema, and cartilage degradation are the main signs and symptoms of RA. When the condition progresses, it gradually destroys bone and cartilage, resulting in permanent bone impairment. The World Health Organization estimates that between 0.3% and 1% of people worldwide suffer from RA, with women three times more likely than males to get the illness. One chronic, systemic autoimmune disease is rheumatoid arthritis (RA).[2]As a component of the intricate biological reaction of vascular tissues to damaging stimuli such as infections, injured cells, and allergens, inflammation occurs. The symptoms include discomfort, fever, redness, swelling and loss of function. It is an intrinsic immune mechanism [3].

Protein denaturation was the primary source of inflammation in rheumatoid arthritis. Sites of inflammation are where protein denaturation takes place, and denatured proteins may be more prone to glycation, a known mediator of inflammation [11]. Denaturation can happen as a result of heating, being near acids or bases, or even from vigorous physical activity. Rheumatoid arthritis inflammation leads to excruciating swelling of joint tissues, which may cause malformed joints and bone loss. Prior studies carried out by Ahmed and his colleagues have indicated that the primary cause of this inflammation is a cytokine protein called interleukin-1 beta (IL-1 beta).[12]

Since denatured proteins are frequently insoluble, they precipitate more frequently, which raises the activity of the macrophase at the tissue's protein de-naturation site and can cause inflammatory and neurodegenerative illnesses.[13]Because conventional drugs have significant adverse effects when used over an extended period of time, managing disorders connected to protein de-naturation presents a significant problem for medical professionals.[14]The clinician attempts to think that using herbal or alternative medication will help with this severe problem. Many modern human drugs are derived from natural resources, which have been a major source of





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medicinal medicines for thousands of years. So, the main goal for researchers going forward is to produce novel plant-based medications with improved bioactive potential and little to no negative effects [15].

Since ancient times, plants have been used as powerful biochemical factories and as components of phytomedicine. Man can extract an amazing variety of industrial chemicals from plants [13]. Plants based natural constituents can be obtained from any part of the plant, meaning that any portion of the plant may contain active ingredients. Examples of plant parts include bark, leaves, flowers, roots, fruits, and seeds. The last three decades have seen the emergence of antioxidant-based drugs and formulations for the inclusion, prevention, and treatment of complicated illnesses like as cancer, diabetes, Alzheimer's disease, stroke, and atherosclerosis [4].

Oxidative stress, which is a major contributor to numerous diseases like cancer, cardiovascular disease, neurodegenerative disease, rheumatoid arthritis, atherosclerosis, hypertension, and AIDS, is brought on by an imbalance between reactive oxygen species (ROS) and the anti-oxidative defense systems [12]. The potential of antioxidants to prevent or postpone oxidative damage by obstructing the start and spread of oxidizing chain reactions has led to the exploration of antioxidant therapy for cellular degenerations. Because of this imbalance, which can cause damage to cellular components including lipids, proteins, and DNA, our bodies produce more reactive oxygen species than antioxidant species when under stress.

A heart-shaped, shiny, white cat can be found on the evergreen betel leaf creeper. Throughout the world's tropical and subtropical climates, the genus *Piper* (Piperaceae) is still abundant. Growing countries for *piper betel* include East Africa, the Philippines, Malaysia, Indonesia, and Sri Lanka. It tastes harsh and has a faint yellow scent from the essential oils.[4] In the world, betel vines come in over 90 species, with nearly 45 of those being found in India and 30 of those being in West Bengal. It is cultivated in tropical and subtropical regions due to its evergreen leaves, which are utilized as a chewing stimulant and in pooja sessions and other religious events [5].

In the Ayurvedic medicine system, the properties of *Piper betel* are described below[6]

- Guna (Quality): Laghu, Ruksha, Tikshan
- Rasa (Nambitha): Tikt
- Vipak (Metabolism): Katu
- Virya (Power): Ushan
- Prabhav (Impact): Hridya

The *Piper betel* flower is composed of long terminal spikes. A single spike can consist of all staminate flowers, almost all hermaphrodite flowers, or partially or entirely pistillate flowers with sporadic staminocia. This is less common.[7]About two millimeters in diameter, the full staminate flowers diameter and a minimum length of five centimeters. When mature, the female and hermaphrodite spikes measure ten to twelve millimeters in thickness and length, matching that of the male counterparts [8]. There could be as many as 500 or 600 blossoms on a spike. Long terminal spikes make up the *Piper betel* flower. All staminate flowers, nearly all hermaphrodite flowers, or partially or fully pistillate flowers with intermittent staminocia can all be found in one spike. This is not as typical.[9]The complete staminate flower's diameter is approximately two millimeters, and its minimum length is five centimeters. The adult female and hermaphrodite spikes are the same length and thickness as their male counterparts, measuring ten to twelve millimeters. On a spike, there could be 500 or 600 flowers [10].

MATERIALS AND METHODS

Collection and Preparation of Extract

Fresh *Piper betel* flowers were gathered from Tanaji Kharat's personal farm. Fresh flowers were twice washed under running tap water, then distilled water and allowed to air dry. The flowers were mixed into a fine powder after they had properly dried. For later use, the flower powder that had been shade-dried was kept at room temperature. Two





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separate pre-labeled conical flasks were filled with one gram of the dried powdered flower, 40 milliliters of de-ionized double-distilled water, and ethanol. The mixes were incubated overnight at 30°C and 120 rpm in a BOD shaker incubator. The mixture was run through Whatman filter number one the next day. Every time, newly made alcoholic and aqueous extracts were employed in the anti-protein de-naturation experiment.

Preparation of Extract- for antioxidant assay

Fresh flowers were gathered, then allowed to air dry at room temperature in the shade. Using a mesh screen, dried flowers were mechanically ground into powder. Seventy percent alcohol was used to extract 100 grams of freshly powdered flowers that had been evenly packed in a soxhlet apparatus. After then, the solvent evaporated at a low temperature and with less pressure.

Chemicals

DPPH (2, 2-diphenyl-1-picrylhydrazyl), gallic acid, and catechin are standard chemicals used to measure radical scavenging activity. These compounds were acquired from Sigma-Aldrich Fine Chemicals (St. Louis, MO). The supplier of TPTZ (2,4,6-tripyridyl-striazine) was Sisco Research Laboratories Pvt. Ltd. (Mumbai, India), while Merck (Darmstadt, Germany) provided the Folin-Ciocalteu reagent, methanol, ethanol, ethyl acetate, acetone, acetic acid, and hydrochloric acid. The antioxidant (PHOTOCHEM) kit that was utilized was purchased from Analytikjena (Konrad-Zuse-Strasse 1, Germany). We bought potassium per sulfate, ferric chloride, hydrochloric acid, anhydrous sodium acetate, acetate buffer, and ferrous sulphate from Central Drug House (Pvt.) Ltd. (New Delhi, India).

METHODS

Phyto-chemical Screening

A fresh betel extract was evaluated for bioactive substances such as terpenoids, saponin, sterols, alkaloids, flavonoids, tannin, carbohydrates, amino acids, and proteins. The usual procedure was used to complete the qualitative analysis.

In Vitro - Protein Denaturation Assay

In this experiment, 2.8 ml of phosphate buffered saline (PBS, pH 6.4) and 2 ml of various concentrations of the test extract (50 µg/ml, 75 µg/ml, and 100 µg/ml alcoholic and aqueous extract of *Piper betel* flower) were mixed to prepare the assay mixture. Additionally, 0.2 ml of egg albumin (from fresh hen's egg) was used as their protein source. The control was an equivalent volume of double-distilled water. After being heated to 70°C for five minutes in a water bath, the mixtures were incubated for fifteen minutes at 37±2°C in a BOD incubator. The vehicle was used as a blank to test their absorbance at 660 nm after cooling. To determine absorbance, diclofenac sodium was utilized as a reference medication at final concentrations of 50µg/ml, 75µg/ml, and 100µg/ml and handled in a comparable manner [16].

Calculations

We used the following formula to get the percentage inhibition of protein de-naturation.

$$\% \text{ inhibition} = 100 \times [V_t / V_c - 1]$$

where

V_c = absorbance of the control sample and

V_t = absorbance of the test sample

In vitro- Antioxidant Activity

DPPH photometric assay

When the 2, 2-diphenyl-1-picrylhydrazylhydrate (DPPH) radical was present, the capacity of *Piper betel* extract to donate hydrogen was tested. In ethanol, it yields a violet-colored solution. [14]. A stock solution of the extract (1.0





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mg/ml) was diluted in ethanol to reach a final concentration of 5, 10, 15, 20, and 25 mg/ml. 2.5 ml of sample solution with varying concentrations was mixed with 1 ml of 0.3 mM DPPH ethanol solution, and the mixture was left to react at room temperature. The absorbance readings at 518 nm were recorded after 30 minutes. As a blank, 1.0 ml of ethanol and 2.5 ml of plant extract solution were utilized. As a negative control, DPPH solution (1.0 ml: 0.3 mM) with 2.5 ml of ethanol was employed. Those utilizing the standard solutions (ascorbic acid) served as the positive control.[8]

Using the following formula, the percentage Antioxidant Activity (%AA) was determined:

$$AA\% = 100 - \left\{ \frac{Abs\ Sample - Abs\ blank}{Abs\ control} \times 100 \right\}$$

The concentration needed at 50% to block or alter absorbance. (IC50) was computed as well.

Measurement of the reductive ability

The Fe³⁺-Fe²⁺ transition in the presence of the extract was examined in order to quantify the reductive ability.[15] 2.5 milliliters of 0.2M phosphate buffer (pH 6.6), 2.5 milliliters of 1% potassium fericyanide [K₃ Fe (CN) 6], and one milliliter of plant extract (1 mg/ml) were incubated at 50 degrees Celsius for 20 minutes. After the liquid was mixed with 2.5 cc of 10% Trichloro acetic acid (TCA), it was centrifuged for 10 minutes at 3000 rpm. A 1.5 ml solution of freshly made 0.1% ferric chloride was added to 2.5 ml of the supernatant, which was then agitated. A 700 nm measurement was made of the absorbance. In place of extract, water was added to the reference solution, which was made similarly to the previous one. A reaction mixture's enhanced absorbance suggests a higher reducing power.[7]

Scavenging of Superoxide anion radical

Xanthine oxidase and hypoxanthine were used in vitro to produce the superoxide anion radical.^[6] A reaction mixture containing 1 mM EDTA and 50 mM KH₂ PO₄ – KOH pH 7.4 was produced, with a final volume of 1 ml per tube. 100 mM NBT and 100mM hypoxanthine. 0.066 U of xanthine oxidase per tube, diluted in 100 ml of phosphate buffer, and 10 ml of saline for the PBLE. The penultimate addition was xanthine oxidase. After five minutes of incubation at 25°C, the absorbance of the reaction mixture was measured at 560 nm. The activity of superoxide anion scavenging increases when the absorbance of the reaction mixture decreases. The findings are given as the percentage inhibition of the NBT decrease rate in comparison to the reaction mixture that contains only saline (no flower extract).^[9]

Inhibition of reaction mixture was calculated by using following formula:

$$I\% = 100 \times \left\{ \frac{A_0 - A_t}{A_0} \right\}$$

where A_t is the absorbance of the test substance and

A₀ is the absorbance of the control.

Molecular Docking

The use of molecular docking in computer-aided drug design and structural molecular biology is essential. An objective of ligand-protein docking is to forecast the main binding mode(s) between a ligand and a protein with a known three-dimensional structure. Many software programs have been created over the past few decades; some of the more well-known ones include AutoDock, AutoDockVina, DockThor, GOLD, FlexX, and Molegro Virtual Docker. Getting the target structure is the initial step in a docking calculation, and it often comprises of a big biological molecule (a protein, DNA, or RNA). The Protein Data Bank (PDB), which offers access to 3D atomic coordinates acquired through experimental techniques, makes the structures of these macromolecules easily retrievable. That the target's experimental 3D structure is unavailable is, nevertheless, not unusual. To get over this problem, the three-dimensional structure of proteins can be obtained using computer prediction techniques including comparison and ab initio modeling.





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Method

Molecular docking has been an essential part of in-silico drug research in recent years. With this approach, the atomic-level interaction between a small molecule and a protein is predicted. This enables researchers to study the behavior of small molecules, such as nutraceuticals, within the binding area of a target protein and to understand the fundamental metabolic process underlying this interaction. The structure-based method requires a high-resolution 3D model of the target protein, which can be obtained by nuclear magnetic resonance spectroscopy, X-ray crystallography, or cryo-electron microscopy³⁻⁵. Both free and paid computational tools and molecular docking techniques are available.

The molecular docking of active constituent was conducted by using V life MDS 4.6 to evaluate *in silico* Antiarthritic activity of the isolated metabolites the X-ray crystal structure of active Capsaicin receptor protein 3J9J as proposed molecular target, was obtained from the RCSB protein data bank (PDB DOI: <https://doi.org/10.2210/pdb3J9J/pdb>). In silico Antioxidant activity of the isolated metabolites was evaluated by using X-ray crystal structure of protein PDB 3EUB was obtained from the RCSB protein data bank (PDB DOI: <https://doi.org/10.2210/pdb3EUB/pdb>). Water molecules and ligands which are not involved in the binding were removed. The protein was prepared using Protonate 3D protocol in MOE with default options. And then molecular docking was carried out by obtaining docking score of two active constituents present in *Piper betel* Flower extract.

- Hydroxychavicol
- Eugenol

Formula for binding affinity of ligand and protein:

$$\text{BindingAffinity}\Delta G =$$

$$\text{Totalenergyofcomplex} - (\text{Uncomplexed}\Delta G.\text{protein} + \text{Uncomplexed}\Delta G\text{ligand})$$

RESULTS

In the current investigation, Table 1 showed the existence of several bioactive compounds in the *Piper betel* extract, and Table 2 showed the aqueous and ethanolic extracts' anti-protein denaturation properties. The same table also included information on the concentrations of the experimental samples and the reference medication.

DPPH assay

The addition of the *Piper betel* flower extract decreased DPPH in a concentration-dependent manner. In terms of IC₅₀, the extract's free radical scavenging activity was 12.0 mg/ml, surpassing the standard drug's ascorbic acid concentration of 5.35 mg/ml. This suggests that the extract may have antioxidant properties.

Measurement of reductive ability

Comparing the *Piper betel* flower extract to the standard, it exhibited the greatest capacity to decrease Fe³⁺ ions and reductive ability (Table.2). A higher reducing power is shown by a higher absorbance of the reaction mixture.

Scavenging of Superoxide anion radical

Ascorbic acid at 50 mg/ml and the alcoholic extract of *Piper betel* flower decreased NBT reduction by 66% and 77%, respectively. Table 3 indicates that the extract's IC₅₀ values were 20 mg/ml and the standard's IC₅₀ values were 22 mg/ml. This indicates that xanthine oxidase activity was suppressed by the extract.

Molecular Docking

Table 6. Comparative scores obtained from molecular docking responses of 2 active constituents (ligand) showing interaction with optimized PDB.





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DISCUSSION

The structural isomers of denatured proteins are incredibly diverse and usually lack the biological activity that were intended for them. Structural and functional characterization of denatured proteins has commonly been viewed as an intimidating and fruitless endeavor due to the intricate structure and absence of biological function. Denatured protein characterization has become more crucial, though, as it has been shown that many inflammatory and neurological illnesses are caused by conformational changes in proteins. A thorough analysis of the various isomers of disease-associated proteins would be necessary in any effort to clarify the cause of these illnesses. Furthermore, it is possible that one of the richest sources of biomolecules that has not yet been utilized for the detection and treatment of disease is conformational isomers of denatured proteins. Animal models are used in pharmaceutical research nowadays, however this has its drawbacks, including ethical concerns and altered bodily homeostasis mechanisms under stressful conditions. We search for alternate approaches from the perspective of fundamental mechanisms as a result of this issue [13]. Therefore, in order to evaluate *Piper betel*'s in vitro anti-inflammatory properties, the protein de-naturation assay methods were chosen for this work. A well-established cause of inflammation-related diseases like arthritis is protein de-naturation, which is one of the main characteristics of inflammatory tissue. It is thought that an agent with anti-protein denaturation properties may one day be employed as a highly effective anti-inflammatory medication.

In India, thousands of tonnes of crop are lost due to lack of exploration in the agro-economy of this crop, particularly in the post-harvest phase. The industrial promise of producing anti-inflammatory drugs and other nutraceuticals from *Piper betel* is therefore promising. The current study assessed *Piper betel*'s in vitro protein denaturation activity in comparison to heat-induced protein denaturation. The chosen plant flower extract exhibits concentration-dependent anti-protein denaturation, according to the current data. Denatured proteins from lysosomal contents were released, triggering an inflammatory reaction that resulted in extracellular release of proteases and neutrophil activation. A qualitative study of the *Piper betel* flower extract indicated the presence of many phytochemicals, including alkaloids, flavonoids, polyphenols, steroids, carbohydrates, and tannins. Many of these bioactive substances have well-established potential biological characteristics. These bioactive substances may be the cause of *Paan*'s or *Piper betel* flower ability to inhibit protein denaturation. Instead of a single effect, there can be a synergistic one.

Piper betel flower extract has the potential to scavenge free radicals on DPPH, as demonstrated by its in vitro antioxidant activity. Rich reductive ability is exhibited by the extracts, which reduced the majority of the Fe³⁺ ions. In comparison with various standards, including ascorbic acid and BHT, the extract exhibited robust scavenging properties against superoxide anion and hydroxy radicals. Free radical scavenging and reduction of free radical-induced cell damage are presumably the antioxidant roles played by *Piper betel* flower extract. The natural antioxidants found in medicinal plants are helpful in reducing or avoiding the harmful effects of oxidative stress. The DPPH free radical scavenging assay and the reducing power assay were used in this study to assess the scavenging abilities of ethanolic extracts of *Piper betel* flowers. Any substance's ability to reduce really depends on the existence of reductants, which have the ability to exhibit anti-oxidative properties by donating an atom of hydrogen to break the free radical chain. In this approach, the ferric (Fe)/ferricyanide complex was reduced to the ferrous form (Fe) by the presence of reductants or antioxidants in ethanolic extracts. The ferrous form (Fe) is thus reached by the concentration procedure. Consequently, Prussian blue from Perl at a wavelength of 700 nm.

Hydroxychavicol and Eugenol Binding Affinity (ΔG) are -74.13 and -54.04, respectively, with a docking score of -4.6639 and -4.1768 when matched with antiarthritis activity. Hydroxychavicol contains one hydrogen bond, but ethanol contains none. A single active molecule, hydroxychavicol, has a docking score of -5.0856, its binding affinity (ΔG) is -99.18, and there are two hydrogen bond interactions, according to molecular docking research on antioxidant activity.





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CONCLUSION

There have been reports that a number of non-steroidal anti-inflammatory medications can prevent protein denaturation. Thus, it can be inferred from the results of this exploratory experiment that *Piper betel* flowers ethanolic and aqueous extract significantly reduced protein denaturation in vitro, but Ethanolic extract reduces more protein denaturation than Alcoholic extract. Thus, additional research should be done to assess this plant's anti-inflammatory properties in the search for newer.

The current studies have so established the antioxidant activity of ethanolic flower extracts of the *Piper betel* plant. From the DPPH assay IC₅₀ value of the extract of *Piper betel* flowers free radical scavenging activity 12.0 mg/ml and Scavenging of Superoxide anion radical IC₅₀ values 20 mg/ml. According to the results of the current research, *piper betel* flowers may be utilized as a natural antioxidant source. We can conclude from in silico studies that hydroxychavicol, a major antioxidant active constituent found in *Piper betel* flower extract, has a major binding affinity, and that eugenol has an affinity for optimized PDB 3J9J. These studies also demonstrate that hydroxychavicol and eugenol have an inhibitory action on COX1 and COX2, which leads to antiarthritic activity.

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Table 1: Extraction of *Piper betel* extract bioactive compound found

Particulars	Observation
Alkaloids	+++
Flavonoids	+++
PolyPhenols	+++
Tannin	+++
Carbohydrate	+++
Saponin	-
Carbonyls	+++
Terpenoids	-
Proteins	+++
Sterols	+++
Triterpenses	+++
Anthraquinon	-





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Table 2: In vitro anti protein denaturation activity of aqueous and ethanolic extract of Piper betel(flower)

Treatment	Concentration($\mu\text{g/ml}$)	% Inhibition
Ethanolic Extract	50	39.05
	75	44.17
	100	48.95
Aqueous Extract	50	30.28
	75	32.50
	100	35.04
Sodium Diclofenac	50	49.00
	75	67.14
	100	85.33

Table. 3. Measurement of DPPH assay

Treatment	Concentration (mg/ml)	%AA	IC ₅₀
Piper betel flower extract	05	44.07 \pm 1.44	12.00mg/ml
	10	47.05 \pm 3.59	
	15	60.34 \pm 5.20	
	20	66.50 \pm 2.90	
	25	72.02 \pm 3.86	
Ascorbic acid	05	47.60 \pm 9.84	5.35mg/ml
	10	55.39 \pm 14.4	
	15	67.42 \pm 7.07	
	20	72.81 \pm 5.33	
	25	76.20 \pm 6.50	

The three parallel measurements' mean \pm SD is shown as the result. %AA is the antioxidant activity percentage. 50% inhibitory concentration, or IC₅₀.

Table. 4. Measurement of Reductive ability of Piper betel flower extract

Treatment	Concentration (mg/ml)	Absorbance
Blank		0.4279 \pm 0.18
Piper betel flower extract	10	0.4403 \pm 0.23
	20	0.4831 \pm 0.42
	30	0.5570 \pm 0.12
	40	0.8087 \pm 0.78
	50	0.8092 \pm 0.65
BHT	10	0.5071 \pm 0.24
	20	0.5823 \pm 0.31
	30	0.6068 \pm 0.28
	40	0.7535 \pm 0.35
	50	0.8562 \pm 0.29

The three parallel measurements' mean \pm standard deviation are the results.





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Table. 5 Scavenging of Superoxide anion radical (NBT)

Treatment	Concentration (mg/ml)	%AA	IC ₅₀
Piper betel flower extract	10	28.01 ± 3.16	20mg/ml
	20	50.77 ± 7.70	
	30	57.01 ± 5.50	
	40	60.50 ± 4.72	
	50	66.24 ± 3.57	
Ascorbic acid	10	34.72 ± 7.43	22mg/ml
	20	48.44 ± 4.05	
	30	56.12 ± 12.5	
	40	68.28 ± 4.96	
	50	77.82 ± 9.89	

The three parallel measurements are combined to get the mean ± SD

Table 6. Comparative scores obtained from molecular docking responses of 2 active constituents(ligand) showing interaction with optimized PDB. Antiarthritis activity

Sr. no.	Compoundname	Dockingscore	BindingAffinity (ΔG)	Interaction
1	Hydroxychavicol	-4.6639	-74.13	1 Hydrogen Bond(TYR175A)
2	Eugenol	-4.1768	-54.04	No Hydrogen bond

Table 7. Comparative scores obtained from molecular docking responses of 1 active constituents(ligand) showing interaction with optimized PDB.

Sr. no.	Compoundname	Dockingscore	BindingAffinity (ΔG)	Interaction
1	Hydroxychavicol	-5.0856	-99.18	2 Hydrogen Bonds (SER1082C)





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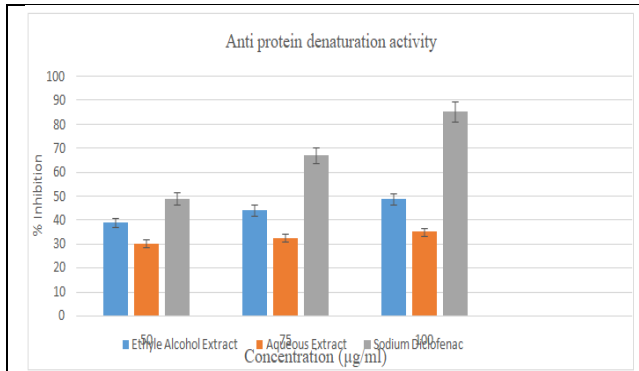


Fig no.3 Comparative analysis of inhibition percentage of protein denaturation in different extract of *Piper betel* flower.

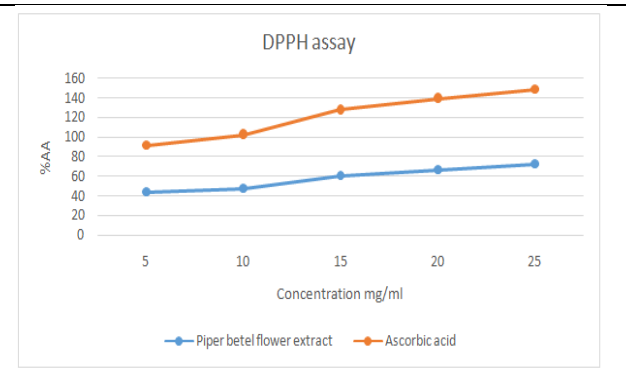


Fig. no. 4 DPPH assay results

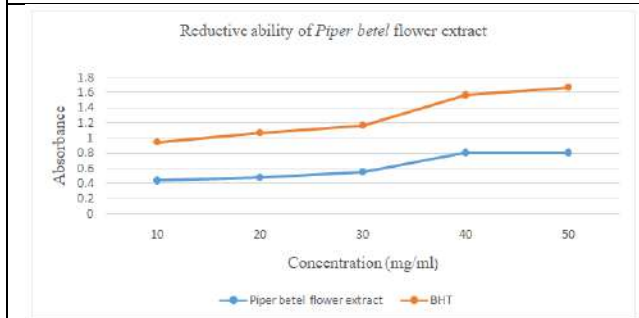


Fig.no .5 Reductive ability of *Piper betel* flower extract Results

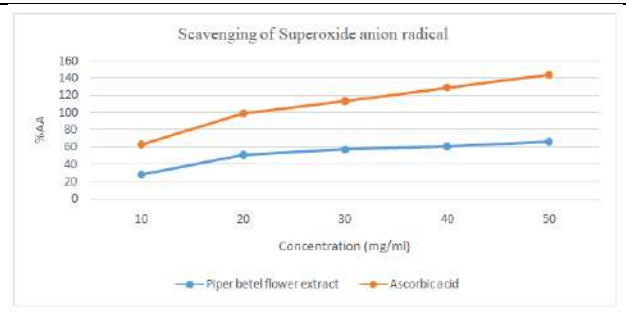


Fig.no.6 Scavenging of Superoxide anion radical results

Anti- Arthritis Activity

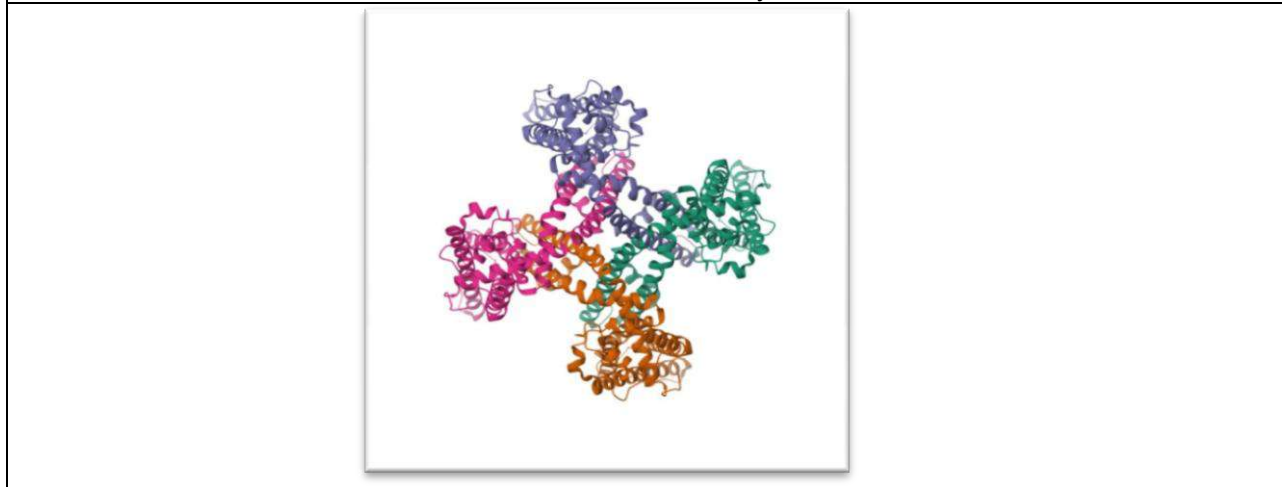


Fig.no. 7 Structure of 3J9J obtained from RCSB protein data bank





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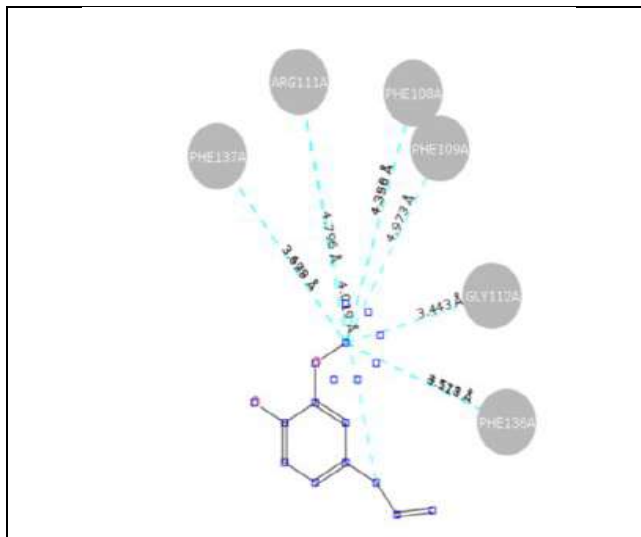


Fig.no.8 Structure showing interactions of Eugenol with 3J9 PDB

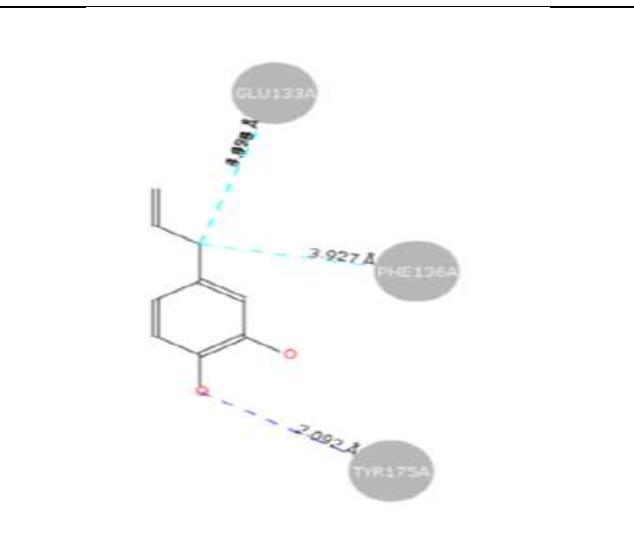


Fig.no. 9 Structure showing interactions of Hydroxychavicol with 3J9 PDB

Antioxidant Activity

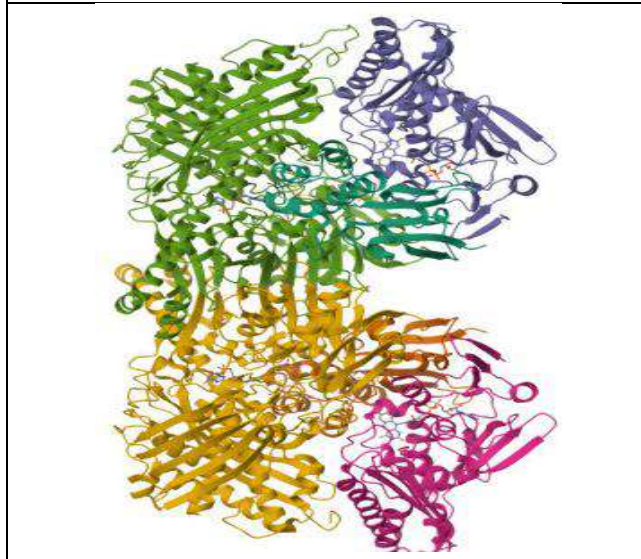


Fig.no. 10 Structure of 3EUB obtained from RCSB protein drug bank

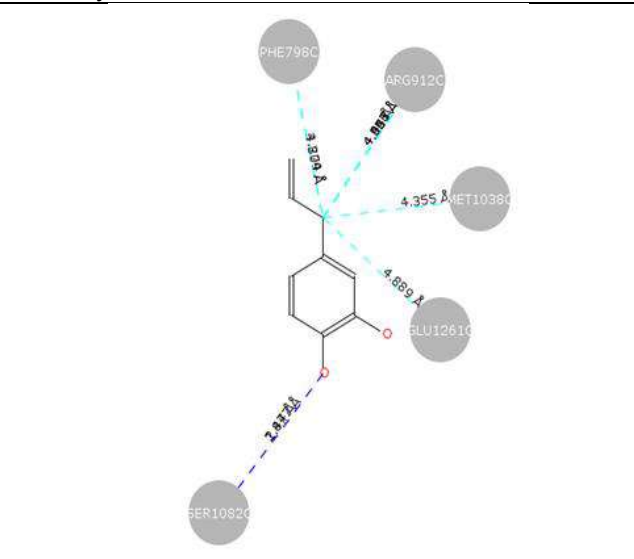


Fig.no. 11 Structure showing interaction of Hydroxychavicol with 3EUB PDB





A Study to Determine Gender Variation of Maxillary Sinus Dimensions by 3D CT in Adult Population of Western Uttar Pradesh Region

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ABSTRACT

The Maxillary sinus is one of the four pairs of paranasal sinuses located in the skull. The maxillary sinus is situated within the maxillary bone, which is the large bone of the upper jaw. There is two MS, one on each side of the nose. The size of the MS can vary among individuals, and it tends to enlarge as a person grows. MS are particularly sensitive to sexual dimorphism in terms of dimensions including volume, length, width and height. Understanding how MS varies by gender has applications in numerous fields such as in radiology, dentistry, clinical diagnosis, surgical planning, gender determination in forensic and earlier disease detection are all possible because to an appreciation of these differences. In cases involving pathology or anatomical anomalies of MS it can increase the accuracy of diagnosis. The significance of this knowledge in disease screening and early management is further emphasised by the possible link between sinus dimensions and systemic disorders. Computed tomography (CT) imaging is a revolutionary way for determining MS dimensions and accurate measurements of sinus. CT scan guarantee excellent accuracy and precision in measurements due to their three-dimensional characters.

Keywords: Maxillary Sinus (MS), Computed Tomography (CT).



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INTRODUCTION

Each side of human skull contains air filled chambers called maxillary sinus or maxillary antra. Due to their diagnostic and forensic importance, sinus is increasingly being examined with imaging methods such as three-dimensional computed tomography (3D CT) scans. Several anatomical structures are found in close proximity to maxillary sinus (Joe Ivanga *et al.*, 2019). Due to their convenient anatomic placement, 3D CT imaging of the maxillary sinus has proven to be of great value in investigations at identifying a person's gender (Gulec *et al.*, 2020). Many anatomical changes, including hypoplasia, antral septa, and bone exostosis, can be seen in the maxillary sinus (Narao Lozano *et al.*, 2017). The possibility of membrane perforation during sinus floor elevation is increased in patients having maxillary sinus septa (A.Hungerbuhler *et al.*, 2019). Anatomical structures which are commonly found include maxillary sinus septa (M.E. Toprak *et al.*, 2021). The maxillary sinus septum formed with the evolution of the middle face region of the skull and is largely developed in all maxillary sinus regions (Young *et al.*, 2011). The volume of the maxillary sinus is correlated with specific characteristics such side, gender, lack of posterior teeth, thickening of the sinus membrane, bony septa, and sagittal and vertical skeletal patterns (Anne Maria *et al.*, 2022). Septa with a transverse orientation are most prevalent in the middle section of the sinus (Henriques *et al.*, 2022).

The ethmoid, sphenoid, frontal, and maxillary sinuses are the four complicated anatomical structures that together make up the paranasal sinuses (Sophie Lee *et al.*, 2022). To distinguish between normal development and unusually massive, hypoplastic, or deformed sinuses, one must be aware of the stages of sinus growth (Adam *et al.*, 2021). There is also a relation between headache and smaller paranasal sinus volume (Levent *et al.*, 2019). The maxillary sinus has two postnatal period at which it grows rapidly 0–3 is the first period's age range, and 7–12 is the second. After the age of twelve, it proceeds to develop slowly until it reaches full maturity. The maxillary sinus became fully mature at the ages between 18-20. After this age any changes in the measurement of maxillary sinus will be sign of pathology and variation of sinus. The shape and size of sinus are affected by many factors including environment, genetics or any kind of infections. A routine implant procedure or tooth extraction could have complications that can affect the craniofacial anatomy. Therefore, it is essential to have a solid understanding of the anatomy and measurements of the maxillary sinus (M. Gulec et al 2020).

Computed Tomography: Basics

Computed Tomography (CT), also referred to as Computerized Axial Tomography (CAT) scan, stands as a pivotal medical imaging technique that has transformed diagnostic medicine by delivering intricate cross-sectional images of the body's internal structures. This imaging modality relies on X-ray technology to generate comprehensive and highly detailed images, empowering healthcare professionals with the capability to observe and scrutinize various anatomical regions with exceptional precision. The advent of CT scans has significantly enhanced diagnostic capabilities, allowing for more accurate and detailed assessments in the field of medical imaging (Seeram. E 2010). X-ray computed tomography (CT) is a non-destructive technique which can disclose an object inside details in three dimensions (Philip *et al.*, 2021). Accurate tissue/organ separation between the various body compartments, such as adipose tissue, skeletal muscle, bones, and organs, is made possible by the high-resolution CT imaging (Michalis *et al.*, 2016). Recent developments in CT technology include extreme multidetector CT, iterative reconstruction methods, dual-energy CT, cone-beam CT, portable CT, and phase-contrast. These advancements are anticipated to have, a substantial therapeutic impact (Daniel Thomas *et al.*, 2014). These developments might be analyzed in terms of how they affect clinical practice, how they enhance performance (Jiang *et al.*, 2021). Due to the rise in CT exams conducted globally, radiation dosage in x-ray computed tomography (CT) has drawn a lot of attention. Patient dosage assessment is still an area in need of progress and global consistency (Willi 2014). Furthermore, with positive results, fresh image reconstruction methods that lower radiation exposure have been developed recently (Stephen *et al.*, 2016). The capacity to collect data in various energy bins is suggested by recent developments in the use of energy-resolving, photon-counting detectors for CT imaging. This is anticipated to further improve the signal-to-





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noise ratio for material-specific imaging (Cynthia *et al.*, 2015). When suitable scan lengths within each imaging procedure are strictly followed, whenever possible, there is great opportunity for dosage optimization (Mohamed *et al.*, 2015). Several technical methods can be used to obtain dual-energy information in computed tomography (Nils *et al.*, 2020). Computed tomography makes it feasible to take measurements with high precision (Saccucci *et al.*, 2015).

Development of Maxillary Sinus

The intricate anatomy of the paranasal sinuses exhibits individual variance. Normative values for the size of the paranasal sinuses and how they vary with age may be useful in determining whether certain disorders affecting the sinonasal area are present (Degermenci *et al.*, 2016). Different maxillary sinus diameters experience development spikes at various Intra Uterine Life phases. Anteroposterior diameter values grow from the start of intrauterine life to the end. Throughout life, male maxillary sinuses stay comparatively larger (Ghaus *et al.*, 2006). Males have larger width of maxillary sinus when compared with females, which is useful in determining gender dimorphism (Franciellen *et al.* 2022).

Pathology of Maxillary sinus

The dental and otolaryngology communities both admit the existence of a well-known disorder called odontogenic maxillary sinusitis (Kasikcioglu *et al.*, 2016). There might be an underlying dental pathology in about 30% of cases of unilateral maxillary sinusitis (George Psillas *et al.*, 2021). The etiology of persistent odontogenic maxillary sinusitis (OMS) was examined using histopathology of the maxillary sinus mucosa, and the significance of endoscopic sinus surgery (ESS) was elucidated (Sato *et al.*, 2020). For individuals with recurrent and refractory sinusitis, functional endoscopic sinus surgery is a successful treatment option. Radiologists can use preoperative computed tomography (CT) to prospectively identify anatomic variants that put patients at risk for significant surgical problems (William *et al.*, 2016). Maxillary sinus mucosal cysts (MMC) are often found during imaging examinations. It has been found that their prevalence can reach 35.6%. Although quantitative study is lacking, it is known from personal knowledge that numerous procedures are carried out to treat isolated MMC in the absence of symptoms (Evangelos I. Giotakis *et al.*, 2013). Mucous retention cysts (MRCs), sometimes referred to as antral or maxillary sinus pseudocysts, are one of the most frequent pathological observations of the maxillary sinus. They typically manifest as a radiopaque soft-tissue mass that is dome-shaped and linked to the sinus's bony walls (Kuofeng *et al.*, 2021). The variants of maxillary sinuses involve hypoplasia and aplasia, maxillary sinus septae, ethmoidmaxillary sinus, superior meatus-draining maxillary sinus, and over-pneumatization. Hypoplasia of the maxillary sinus is an exceptional disorder. Most people don't have any symptoms, although occasionally they experience facial pain and headaches (Banu Atalay 2021). Many of the maxillary sinus pathology can cause severe symptoms which lead to admit patients in departments like dentistry, Surgery, ENT (Adin Selcuk *et al.*, 2008). For otolaryngologists, rhinologists, oral and maxillofacial surgeons, dental and maxillofacial radiologists, the knowledge of maxillary sinus dimensions is crucial (Whyte *et al.*, 2019). As one of the most prevalent congenital craniofacial defects, cleft lip and palate (CLP) can alter the morphology of the maxillary sinus, skull, and face because it disrupts the fusion of the palatal shelves (Yassaei *et al.*, 2023). Neurilemmoma, also known as Schwannoma, is a benign tumor that develops from Schwann cells that surround the nerve sheaths of the autonomic or peripheral nervous systems, particularly the sympathetic nervous system (Bader *et al.*, 2018). The most frequent sinonasal tumors are polyps and mucocele, while schwannoma is infrequently discovered in the paranasal sinuses (R.S.Minhas *et al.*, 2013). Under general anesthesia, a combination of endoscopic medial maxillectomy with Caldwell-Luc operation can be performed to eliminate the encapsulated mass entirely (Turgut *et al.*, 2022).

The majority of incidental findings don't need to be treated, but some will need the treatment plan to be adjusted. Consequently, anatomical variances and incidental findings should be known to dental practitioners. If these findings are correctly identified, fewer needless additional diagnostic evaluations can be performed, and more suitable treatment options can be chosen (Hakan *et al.*, 2018). Before any treatments that involve close approach to the sinus floor, like tooth extraction, implant insertion, and sinus floor elevation, it is crucial to visualize and evaluate the maxillary sinus (Andy *et al.*,) 20





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Clinical Applications of dimensions

Anatomic variability across genders has been found by maxillary sinus measurements, and this methodology can be used as a supplementary tool for human identification in forensics. (Nikolas *et al.*, 2023). By evaluating dimensions of maxillary sinus, gender can be identified (Oguzhan *et al.*, 2014). A trustworthy method for determining gender is the morphometric examination of the maxillary sinus (Tanya *et al.*, 2017). Maxillofacial and oral surgery heavily relies on accurate measurements of the maxillary sinus. Sinus dimensions might vary by gender, which can affect preoperative planning. To avoid difficulties during sinus floor elevation or implant insertion, surgeons must be aware of variances in the size and position of the maxillary sinus. Since septa are frequently present and are detected in one-third to roughly half of the investigated cases, a thorough inspection is necessary before doing any surgical procedures in order to prevent any potential consequences (Amani *et al.*, 2023). Before doing any maxillary sinus augmentation, a thorough assessment of various anatomic anomalies must be carried out, especially in elderly individuals (Mohammed *et al.*, 2020). Accurate and risk-free surgical procedures are made possible by the anatomical insights provided by 3D CT scans. The posterior maxilla is a typical area for dental implant insertion. The importance of knowing the maxillary sinus's size cannot be overstated. Gender differences can affect how long implants are and where they're placed. For men with larger maxillary sinuses, for instance, the implant may need to be longer or the sinus floor elevated. However, women with narrower sinuses may have to adjust how their implants are placed (Mathew *et al.*, 2020).

DISCUSSION

To get a complete picture of the range of maxillary sinus volume, the study included participants of varying ages and sexes. Cone beam computed tomography (CBCT), which provides high-resolution, three-dimensional imaging, was the principal technique used to record the maxillary sinuses' anatomical structure. The data was analysed to reveal potential differences in maxillary sinus size across the sexes and age groups. Ex differences in maxillary sinus size were validated by the research. In every three-dimensional CBCT analysis, males were found to have larger maxillary sinuses than females. Consistent with prior investigations, this one found that maxillary sinus diameters differ by gender. The consistency of the results across age groups demonstrates the validity and strength of the study. The use of CBCT enabled more accurate measurements, strengthening the reliability of the results. This research underlined the precision and potential of CBCT in determining maxillary sinus architecture. It demonstrated the value of this imaging method for comprehending differences between the sexes along these lines. Clear evidence of sexual dimorphism in maxillary sinus dimensions was found in the study by Aktuna Belgin and her colleagues, who used CBCT for three-dimensional evaluation. Consistency in findings across age groups demonstrates the validity and versatility of this approach. This study's use of CBCT demonstrates the reliability and promise of this imaging modality for determining gender based on maxillary sinus morphology (Aktuna Belgin *et al.*, 2019).

Researchers in Oral Radiology look at the posterior maxillary region, which is hard for dentists to work with because of its intricate architecture. Cone beam computed tomography (CBCT) scans from 212 patients will be analyzed in this study in order to ascertain the average diameters and frequency of maxillary sinus abnormalities by age and gender. This information is clinically important for surgery; hence the study also looks at how changes are influenced by maxillary sinus sizes. 77.8% of the time, at least one anatomical variation occurs; the most frequent variant is the auxiliary ostium. The investigation examines whether gender, age, and variations impact maxillary sinus morphometry using chi-square, independent t, and one-way Anova. The conclusion emphasizes comprehensive pre-surgical screening to prevent problems because of usual anatomical variances. The study by Ayyildiz and Akgunlu highlights the three-dimensional evaluations of CBCT. This enhances the precision and security of challenging maxillary posterior dental procedures (Ayyildiz & Akgunlu, 2023).

All of the maxillary sinus measurements were taken using computed tomography (CT) scans, a non-invasive and extremely precise imaging method. The study's major aim was to look into whether or not there is a difference in the size of the maxillary sinuses between sexes, hence it included both males and females in its cohort. In order to get



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precise measurements, Sharma and his group used 3D CT scans to get detailed images of the maxillary sinuses. Maxillary sinus diameters differed significantly between sexes, as demonstrated by this study. The maxillary sinuses of males were measured and found to be significantly larger than those of females. The existence of sexual dimorphism along these dimensions was therefore highlighted. The maxillary sinuses were studied for their volume, length, width, and height, all of which contributed to the reliable separation of the sexes. This study highlighted the importance of maxillary sinus measurements outside of the forensics field. Maxillofacial surgery, orthodontics, and even general medical imaging can all benefit from a deeper understanding and quantification of these differences. The therapeutic importance of the study was further emphasised by the exact measurements obtained by 3D CT scans, which increased the dependability of these findings (Sharma *et al.*, 2014).

A study was conducted on maxillary sinus development in children up to 18 years old, published in the International Journal of Paediatric Otorhinolaryngology. Clinically, understanding how the maxillary sinus changes in size and volume with age helps evaluate radiographs and discover irregularities. The research of CT scans from 170 participants across 17 age groups shows a continuous maxillary sinus growth trajectory from birth to 18 years. Changes are noticeable in horizontal, vertical, and antero-posterior dimensions. Although bilateral dimorphism is absent, gender differences appear in children above 8. According to the study, most growth occurs in the first eight years, and all diameters and volumes peak by the sixteenth year. The study shows that CT scans may reliably assess age-related maxillary sinus changes. This wealth of developmental data helps us comprehend sinus growth, which enhances early sinus anomaly diagnosis and clinical evaluations in children (Lorkiewicz-Muszyńska *et al.*, 2015). Maxillary sinus sexual dimorphism is investigated in a study with cone beam computed tomography (CBCT). CBCT measurements were made of the bilateral maxillary sinus width, length, height, area, perimeter, and volume in 100 patients (50 males and 50 women). For most measures, there are no significant gender differences according to the statistical analysis's unpaired t-tests. Nonetheless, the left side maxillary sinus width of the female group displayed statistically significant greater values, suggesting that it may, with 60% accuracy, determine gender. In forensic anthropology, discriminative analysis reveals that the maxillary sinuses more precisely, its width—can predict gender 71% of the time. (Urooge & Patil, 2017).

A study was done to look at how children's maxillary sinus volumes changed with age. 150 children, ages 0 to 18, had their height, width, and depth measured by CT. The investigation reveals noteworthy patterns of maxillary sinus growth. In every age group, maxillary sinus height increases gradually from birth to age 18. Children under the age of six and those beyond the age of twelve have markedly broader and deeper maxillary sinuses, which indicate distinct phases of growth expansion. The maxillary sinus does not enlarge in width, depth, or volume after 12. This makes the finding puzzling. The complex dynamics of the maxillary sinus during childhood are clarified by this work. Age-specific development patterns are useful to researchers and physicians because they highlight typical disparities. The work of Bhushan *et al.* highlights the significance of taking into account a variety of elements in order to comprehend the complex development of the maxillary sinus during childhood (Bhushan *et al.*, 2016).

Using CT scans, the study evaluated children ages 0 to 18 for potential sexual dimorphism of the maxillary sinus. The study involved the retrospective examination of 170 patients, aged 0-18 (85 females and 85 males), whose CT scans of the head were deemed normal by radiologists. All the patients had their maxillary sinuses measured bilaterally in three planes. The maximum vertical diameter (the maxillary sinus height, MSH); maximum anteroposterior diameter (the maxillary sinus length, MSL); and maximum transverse (horizontal) diameter (the maxillary sinus width, MSW) were measured. Depending on the ontogenesis stage, the sexual dimorphism of maxillary sinus characteristics varies. Males have larger maxillary sinuses at 2-3 years old according to all examined criteria (Agnieszka *et al.*, 2020).

Patients with cystic fibrosis (CF) deal with a severe systemic condition that impacts many facets of their lives. The children with the disease and the control group's computed tomography (CT) scan findings were analyzed. 126 pictures of healthy children aged 0 to 18 and 114 CT images of the study group's children were included in the study. Analysis was done on the frontal, sphenoid, and maxillary sinus volumes. The outcomes were statistically evaluated





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and compared with those of the control group. Statistically significant differences were seen between the study and control groups, despite the fact that both groups' paranasal sinus volumes and developments grew with age (Agata *et al* 2024). The purpose of this research is to measure the maxillary sinus volumes and areas in patients with clinically unilateral sinus disease. A total of 50 individuals (28 men and 22 women, ages 43.6 years (SD = 18.3), had their contralateral sinuses measured, 50 of which had pathological sinuses and the other 50 of which were healthy. The afflicted sinuses had a three-dimensional occupation volume of 97.1 mm³ (62.5%), while the healthy sinuses had a volume of 40.6 mm³ (22.8%) ($p < 0.0001$). In the frontal plane, the group with cysts had a substantially wider medial-lateral sinus (32.4 mm, CI: 23-41.8 mm) (Mario *et al.*, 2020).

This study sought to determine if sex could be ascertained by using maxillary sinus measures from CBCT scans. One hundred patients (fifty males and fifty females) had their maxillary sinus width, length, and height measured using CBCT pictures. One hundred patients (fifty males and fifty females) had their maxillary sinus width, length, and height measured using CBCT pictures. Male and female differences in the measured parameters were compared using the student's t-test and discriminant function analysis. 78% of females and 74% of males correctly predicted their sex, for an overall accuracy of 76%. Maxillary sinus height was the most noticeable factor in the distinction of sex groups, according to discriminant analysis (Maryam 2017). The average age of 60 adults (31 females and 29 males) was found to be 29.90 ± 10.91 years. They were categorized into three groups based on skeletal vertical face growth patterns: high-angle, low-angle, and normal-angle participants. Using CBCT images, the maxillary sinuses' morphological and dimensional alterations were assessed. In terms of the right maxillary sinus length parameter, the low-angle vertical growth pattern group achieved noticeably superior outcomes than the high-angle group (Ridvan 2017).

The aim of the current investigation was to create an automated instrument that measures the combined air-free and total volume of the maxillary sinus by utilizing computed tomography images. The quantification tool aims to normalize measurements of maxillary sinus volume, so enabling improved analyses and comparisons of the variables affecting maxillary sinus size. The automated instrument made use of morphological operators, thresholds, and watersheds in image processing. In thirty patients, the maxillary sinus volume was measured. To assess the precision of the automated technology, and the outcomes were contrasted with segmentation carried out manually by a skilled radiology professional following a defined protocol. For the total and air-free maxillary sinus volume, the mean percent differences between the automated and manual approaches were $7.19\% \pm 5.83\%$ and $6.93\% \pm 4.29\%$, respectively (Guilherme *et al.*, 2018).

The purpose of this study was to use computed tomographic (CT) scanning based on gender to measure the dimensions of the right and left maxillary sinus in Turkmen ethnic groups living in Gorgan, northern Iran. 100 individual's maxillary sinus were measured after scanning. Males had greater width, height, and volume of the left and right maxillary sinuses than females (Arash *et al.*, 2021). An analysis of the impact of concha bullosa variation on maxillary sinus volume and uncinata angle was conducted. The maxillary sinus volume, uncinata angle, and presence of concha bullosa were measured from the paranasal sinus computed tomography of these patients. maxillary sinus volume and the uncinata angle were same in patients with and without concha bullosa (Uygar *et al.*, 2014). Maxillary sinus evaluation requires radiographic inspection, particularly on CBCT pictures, there is a clear correlation between maxillary sinus septa occurrence and ostium height. It was discovered that the size of maxillary sinus drainage system was not significantly impacted by nasal septal deviation, concha bullosa, Haller cells, or other sinusopathies (Gulsun *et al.*, 2020).

CONCLUSION

The size of the maxillary sinuses has been shown to vary by sex in a large number of studies. The maxillary sinuses of males are larger than those of females in terms of volume, length, width, and height. Understanding how maxillary sinus size varies by gender has applications outside of forensics. It has applications in radiology, anatomy, dentistry,





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illness screening, therapy monitoring, clinical diagnosis, and surgical planning. Better patient care, precise surgical planning, fewer surgical complications, and earlier disease detection are all possible because to an appreciation of these differences. In cases involving pathology or anatomical anomalies of the maxillary sinuses, it can increase the accuracy of the diagnosis.

Knowing that men and women have different sized maxillary sinuses is crucially important. Because of this information, doctors may give patients more individualised care. Being aware of these differences is vital for achieving positive results whether diagnosing sinusitis, planning orthodontic operations, performing maxillofacial surgeries, or implanting dental prostheses. The significance of this knowledge in disease screening and early management is further emphasised by the possible link between sinus dimensions and systemic disorders. The clinical implications of maxillary sinus dimensions can be explored further in future studies. The implications of these differences on related medical fields and subpopulations of patients can be investigated.

The gender differences in sinus dimensions can be used in future research to produce individualised medicinal and surgical procedures. Care for patients and the success of treatments can both benefit from this method. Radiological methods of measuring the size of the maxillary sinuses need to be improved as technology advances. This could further boost diagnostic skills and improve patient care. Future research may benefit from focusing on the possible connections between systemic disorders and the size of the maxillary sinuses. If these associations can be understood, perhaps diseases can be detected and treated sooner. The maxillary sinuses and their anatomical variations should be a mandatory element of any medical or dental curriculum. For more precise instruction and diagnosis, more study can aid in the creation of educational methods and resources that take into account differences between the sexes.

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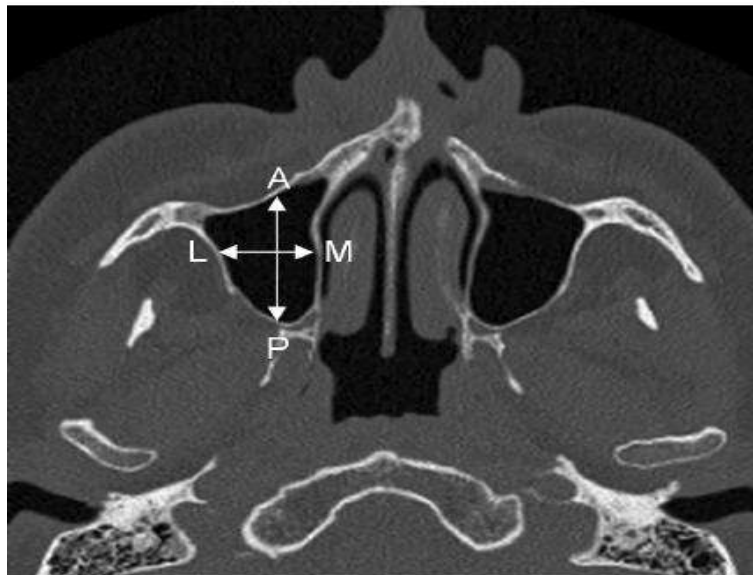
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Fig.1. Serial axial slice showing measurement of the maxillary sinus dimensions: anteroposterior (AP) and mediolateral (ML) measures were performed at 5, 10, 15 and 20 mm above the most apical level of the maxillary sinus floor.





Class IV Laser Therapy on Ejection Fraction, Cardiac Biomarker and Functional Outcomes in Acute Coronary Syndrome: Randomized Sham Controlled Trial Protocol

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ABSTRACT

Acute Coronary Syndrome (ACS) is a major health issue that adversely affects survival as well as Disability Adjusted Life Years (DALYs). Early reperfusion is extremely important and a key component in the management of ACS. However, the process of reperfusion is also associated with myocardial reperfusion injury for which no preventive measure has been proven unequivocally effective. Aim of this trial is to explore the possible value of Class IV laser therapy in limiting myocardial reperfusion injury and thereby improving cardiovascular outcomes. This randomized sham-controlled trial is a prospective study which includes 60 individuals with ACS who satisfy selection criteria will be randomly assigned

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into two groups by block randomization. All the participants will receive guideline directed interventional and pharmacological therapy on discretion of treating cardiologist irrespective of randomization group. Experimental group will be given Class IV laser over 3 spots in 2nd, 3rd and 5th Intercostal Spaces for duration of 60 seconds at each spot, whereas in the control group laser probe will be placed over the same spots but the laser energy will not be delivered. Ejection fraction will be assessed at baseline and on third day, post intervention. Troponin I will be assessed at baseline, peak hours (at 10 hours after PCI) and 3rd post intervention. Functional outcomes will be assessed at baseline and after one month follow up. The trial will provide evidence for efficacy of class IV laser therapy to reducing myocardial reperfusion injury and improving cardiovascular outcomes among the individuals undergoing percutaneous coronary revascularization for ACS.

Keywords: ACS, Cardiac Biomarkers, Class IV Laser, Ejection Fraction.

INTRODUCTION

Acute Coronary Syndrome (ACS) is a major health issue that adversely affects survival as well as Disability Adjusted Life Years (DALYs) which accounts for approximately annually 7 million deaths and 129 million DALYs [1, 2]. In India, CVD accounts for one fourth of all mortality [3]. Early reperfusion of the ischemic area followed by coronary artery occlusion is accepted, extremely important and a key component in management of ACS to reduce size of infarction and improving cardiovascular outcomes [4, 5]. Reperfusion of an ischemic cardiac tissue (ischemia of more than 45 minutes) itself induced myocardial injury and death of cardio myocytes, phenomenon called as myocardial reperfusion injury [5, 6]. Some experimental studies suggest that reperfusion injury accounts for upto 50% of the final size of infarction [5]. However, currently there is no preventive measure has been proven unequivocally effective to prevent this myocardial reperfusion injury in post revascularization patients [7]. Photobiomodulation in the form of low level laser therapy (LLLT) is a novel cardiac intervention which reduces the infarct size, decreases inflammation and scarring, controls cardiac damage as evidenced by bio-marker levels and enhances tissue repair [8]. Effects of LLLT in cases of myocardial injury are well documented in in-vivo and in-vitro animal models, as well as in human clinical trials to prevent myocardial reperfusion injury. Class IV laser is a recent advancement in the field of laser therapy which overcomes the limitations of low level laser, as it has higher tissue penetration.

Study objectives

This is a pre- post test randomized sham controlled trial to assess the effectiveness of class IV laser to limit the myocardial reperfusion injury.

MATERIAL & METHODS

The study is a pre-post test randomized sham controlled trial; Figure 1 shows an overview of this trial plan. The Helsinki Declaration (updated, 2013) and National standards for biomedical and health research involving human subjects (Indian Council of Medical Research, 2017) shall serve as the guidelines for this study. The Maharishi Markandeshwar Institute of Medical Sciences & Research's Institutional Research Ethics Committee gave its approval for this study at Mullana-Ambala, Haryana, India vide project ID: MMDU/IEC/2157. The trial is registered at clinicaltrials.gov (NCT05160519) on 02/12/2021 and Universal Trial number is U1111-1270-8393. This trial will follow the spirit (standard protocol items for randomized trials) guidelines.

Study Population

This experiment will involve people who have been diagnosed with acute coronary syndrome, have had angioplasty with drug-eluting implantation, are older than 18, and are hemodynamically stable. People with growths or tumors



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near the mediastinum; those with pacemakers, either implanted or temporary; having left ventricular ejection fraction (LVEF) $\leq 30\%$; who are receiving photosensitive drugs; pregnant and epileptic individuals will be excluded from this study. Study procedure will be informed to the selected participants and asked to sign an informed consent for their voluntary participation. Using the effect size of 0.8 and the study's power of 80%, the sample size was determined using the G power program, version 3.1.9.4 (Heinrich Heine University Dusseldorf, North Rhine-Westphalia, Germany). Minimum sample size required is 54 (27 in each group). We planned to recruit a total sample size of 60, 30 individuals in each group including 10% dropout rate.

Randomization and Blinding

Block randomization procedure will be conducted manually by drawing 60 blocks (15 rows with 4 blocks in each row). The primary investigator is a more than five year experienced cardio-respiratory therapist who provide laser irradiation and the cardiologist who perform echocardiography, the lab technician who assess cardio biomarker will be blinded. Laser protected eye wears will be used for participants blinding.

Study Procedure

After assessing the baseline outcome measures, the experimental group will be irradiated with Class IV laser for three days; immediately (within 30 minutes) after the angioplasty and subsequent two days. The irradiation will be given at three areas over the pericardium (left sternal border to mid clavicular line in the 2nd, 3rd intercostal space and over the apex) [10] for a duration of 60 seconds at each point as shown in figure 2. The dosage of laser irradiation will be 6J/cm² over three areas for 60 seconds at each area with a laser power of 6W and wavelength of 980nm using LCT-1000C (LiteCure Medical). Total energy delivered over one area will be 360J. During the irradiation phase, the probe will be placed perpendicularly and in direct contact with the skin. ECG rhythm and other vitals will be keenly observed during the entire period of irradiation. To maintain laser standard practice, both the participant and the laser provider will wear laser-protected eyewear. The sham control group, on the other hand, will have the identical class IV laser probe over the same regions, but laser energy will not be given. All the participants will receive pharmacological therapy on discretion of treating cardiologist irrespective of randomization group.

Outcome measures

Basic demographic details and medical history will be taken prior to the outcome measures.

Cardiac Biomarker

Troponin is the best marker for definitive diagnosis of acute myocardial injury [11]. Troponin I is used as an early marker as it is more sensitive. Normal reference range of troponin I is 0.04ng/ml [12]. Cardiac Biomarker Troponin I will be assessed by lab investigations. Troponin I will be evaluated at three times: at baseline, at peak hours (after 10 hour of PCI) and on third day post intervention.

Ejection Fraction

One clear way to measure the left ventricle's systolic function is to look at its left ventricular ejection fraction (LVEF). Normal range of LVEF as per the European Association of Cardiovascular imaging and American society of Echocardiography is 52%-72% and 50%-70% as per the American college of Cardiology, and less than 30% is labeled as severe dysfunction [13]. LVEF will be assessed by Philips EPIQ 7 echocardiography and at two time periods: baseline and third day post intervention.

Functional outcomes

A self-administrated Seattle Angina Questionnaire (SAQ) will be used to assess functional status and Quality of life in patients with coronary artery disease. It measures all five major domains of health related quality of life- physical limitation, angina stability, angina frequency, treatment satisfaction and quality of life [14, 15]. SAQ will be assessed at baseline and after one month follow up. Figure 3 shows the enrollment, intervention and assessment schedule.





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The chairman of the student project committee will lead the Data and Safety Monitoring Committee (DSMC), which will keep an eye on the data that is gathered and will routinely audit the trial. All this will not be informed to the primary researcher.

RESULTS/ STATISTICAL PLAN

The Statistical Package of Social Sciences (SPSS) version 20 will be used for analysis. Kolmogorov-Smirnov test will be used to assess normality of the data. For normally distributed data, the descriptive statistics will be expressed as mean \pm SD and 95% confidence interval and Paired t test will be used for within group comparison and unpaired t test for between the group comparison. For not normally distributed data, the descriptive statistics will be expressed as median (interquartile range) with range and Mann-Whitney U test will be used for within group comparison and Wilcoxon signed rank test for between the group analysis. Statistical significance will be set at $p < 0.05$ to minimize type 1 error. Post hoc power analysis will be performed using G power to verify whether the study attained sufficient power or not.

DISCUSSION

In this study, we intend to determine the efficacy of Class IV Laser therapy in improving cardiovascular outcomes in individuals undergoing percutaneous coronary intervention for ACS. We hypothesized that class IV laser therapy can have beneficial effects on LVEF, cardiac biomarkers and SAQ amongst individuals with acute coronary syndrome after undergoing coronary angioplasty. Myocardial reperfusion injury results as a complex redox stress response. Any mechanism which may change this deleterious redox stress response into a protective redox reaction is essential to avoid this injury [16]. Multiple molecular and cellular mechanisms including mitochondrial respiration, mitochondrial signaling, modulation of inflammatory cytokines, pro-angiogenic and antioxidant actions of laser therapy in the form of low level laser therapy has been observed in number of animal trials [8, 17]. Most of the studies conducted among the animal model and *in-vitro* with low level laser therapy, were found to be effective in improving myocardial infarction size, improving inflammatory profile, reducing oxygen free radical and scarring of tissue [18, 19, 20, 21, 22, 23, 24]. In a human trial, the low level laser therapy after CABG is found to be effective in reduction of cardiac cellular damage and enhancing the tissue repair [10]. Post STEMI, LLLT to bone marrow is also effective to improve Troponin level without any delay in door to balloon time [25]. Low level laser therapy has its limitations as it has less deep penetration [26] with the help of class IV laser therapy we can overcome this limitation. So we can anticipate better outcomes with its use. In this trial, we are limiting the type 1 error less than 5% and type 2 errors less than 10% and this maybe the first study in exploring the cardioprotective effects of class IV laser therapy. Limitation of this trial can be single centered study and short duration of the intervention. This trial can be extended to assess the efficacy of class IV laser with different wavelength and power output and on other cardiac biomarkers like Myoglobin, BNP also. Study can also be conducted among individuals with coronary artery disease other than ACS.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.





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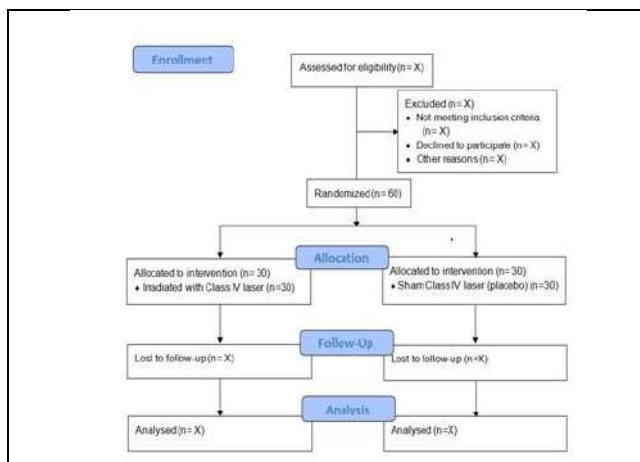


Figure 1: Flow Diagram of the study

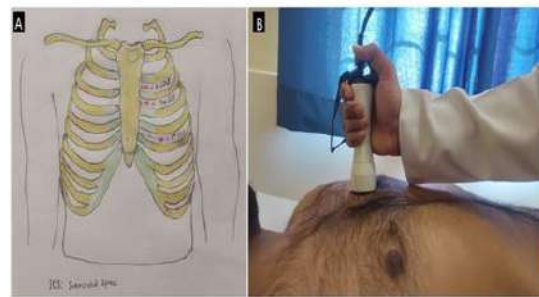


Figure 2: Placement of laser probe





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Figure 3: Schedule of enrollment, intervention and assessment

	STUDY PERIOD							
	Enrolment	Allocation	Post-allocation (treatment)			Follow-up (evaluations)		
TIMEPOINT**	Day 1	Day 1	Day 1 (Within 30 minutes after angioplasty)	Day 2	Day 3	10 hour post angioplasty	Day 3	Follow up at 1 month
ENROLLMENT:								
Eligibility screen	X							
Informed consent	X							
Randomization		X						
Allocation		X						
INTERVENTIONS:								
Group A: Experimental			X	X	X			
Group B: Sham Control			X	X	X			
ASSESSMENTS:								
Troponin I		X				X	X	
Ejection Fraction		X					X	
Seattle angina Questionnaire		X						X





On Disconnected Spaces via Liberal Class of Sets

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ABSTRACT

The main objective of this paper is to establish a novel concept of disconnectedness in topological spaces. We aim to examine the new spaces namely j -disconnectedness and extremally j -disconnectedness using j -open sets. We also attempted to explore its properties using theorems and suitable examples.

Keywords and Phrases : j -open set, j -separated set, j -disconnected, extremally j -disconnected.

2020 Mathematics Subject Classification: 54G05

INTRODUCTION AND PRELIMINARIES

Connectedness is the massive topological property. In the same time we discuss the other side of connectedness equally disconnectedness in topological spaces. Many researchers have focused on finding various types of disconnectedness such as basically disconnected, extremally disconnected, perfectly disconnected and totally disconnected in topological spaces [6,11]. Of all these areas extremally disconnectedness has peculiar applications in topological spaces. Majority of researchers have examined this area of disconnectedness [2, 10]. In 1967, Dona discusses the characterization of disconnected spaces among Hausdorff spaces [4]. In 2013, Majid Mirmiran found the various equivalent statements of extremally disconnected spaces [5]. Sanjay Mishra introduced alpha τ -disconnectedness and investigates the relationship between alpha τ -disconnected and alpha τ -connected sets in 2015 [7]. Recently, Researchers examined various properties of disconnected spaces in different topological spaces [3,9]. Motivated with these researchers we aimed to examine a new spaces called j -disconnectedness and extremally j -disconnectedness in topological spaces using j -open sets. We also made an attempt to explore the properties of these spaces using theorems and suitable examples.

Throughout this paper (X, τ_X) denotes the topological space τ on X .

Definition 1.1 Let (X, τ_X) be a topological space (X, τ_X) is said to be j -open if $R_1 \subseteq \text{int}(pcl(R_1))$. The





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Definition 1.2. [1] Let (X, τ_X) be a topological space and R_1 be any subset of (X, τ_X) , then

The interior of R_1 is the union of all j-open sets contained in R_1 and it is denoted by $int_j(R_1)$. i.e., $int_j(R_1) = \bigcup \{M : M \text{ is j-open set and } M \subset R_1\}$.

the closure of R_1 is the intersection of all j-closed sets containing R_1 and it is denoted by $cl_j(R_1)$. i.e., $cl_j(R_1) = \bigcap \{N : N \text{ is j-closed set and } R_1 \subset N\}$

Remark 1.3. [1] If R_1 is a subset of any topological space (X, τ_X) . Then

R_1 is j-open if and only if $int_j(R_1) = R_1$

R_1 is j-closed if and only if $cl_j(R_1) = R_1$

The family of all j-open sets of a topological space is denoted by $JO(X)$ (or) τ_j .

Remark 1.4. [2] If R_1 and R_2 are any two subsets of $(, \tau_X)$. Then the following statements are hold.

$$int(\phi) = \phi$$

$$cl(\phi) = \phi$$

$$int(X) = X$$

$$cl(X) = X$$

$$int(R_1 \cap R_2) \supseteq int(R_1) \cap int(R_2)$$

$$cl(R_1 \cup R_2) \subseteq cl(R_1) \cup cl(R_2)$$

$$int(R_1) \subseteq R_1$$

$$cl(R_1) \supseteq R_1$$

Definition 1.5. [8] Let (X, τ_X) be a topological space if the two nonempty subsets R_1 and R_2 of (X, τ_X) is said to be j-separated if and only if $R_1 \cap cl_j(R_2) = \phi$ and $cl_j(R_1) \cap R_2 = \phi$.

Definition 1.6. [8] A topological space (X, τ_X) is said to be j-connected if $X \neq R_1 \cup R_2$ where R_1 and R_2 are j-separated sets in X .

Definition 1.7. [7] A topological space (X, τ_X) is said to be disconnected if X can be expressed as a union of two non-empty open sets in X . i.e., $X = R_1 \cup R_2$ where R_1 and R_2 are two sets with $R_1 \cap R_2 = \phi$.

Definition 1.8. [5] A topological space (X, τ_X) is called as extremally disconnected if $cl(R_1)$ is open for every open sets R_1 of (X, τ_X) .

Definition 1.9. [3] A fuzzy topological space (X, τ_X) is said to be extremally fuzzy α -disconnected if $cl_\alpha(\lambda)$ is fuzzy α -open for every fuzzy α -open sets of (X, τ_X) .

Definition 1.10. [7] Let (X, τ_X) and (X, τ_α) be two topological spaces. Then R_1 and R_2 of (X, τ_X) are said to be α - τ separated if and only if R_1 and R_2 are non-empty, $R_1 \cap cl_\alpha(R_2) = \phi$ and $cl_\alpha(R_1) \cap R_2 = \phi$ also $R_1 \cap R_2 = \phi$

j-disconnected spaces

Definition 2.1. A topological space (X, τ_X) is said to be j-disconnected if X can be expressed as a union of two non-empty j-separated sets in (X, τ_X) .

Example 2.2. Consider $X = \{q, r, s, t\}$ and $\tau_X = \{\phi, \{q\}, \{r, s, t\}, X\}$. For this topology, we have $\phi, \{q\}, \{r, s, t\}$ and X are j-open sets. Then $X = \{q\} \cup \{r, s, t\}$. Since $\{q\}$ and $\{r, s, t\}$ of (X, τ_X) are j-separated sets. i.e., $\{q\} \cap cl_j\{r, s, t\} = cl_j\{q\} \cap \{r, s, t\} = \phi$. Thus (X, τ_X) is a j-disconnected space.

Theorem 2.3. A topological space (X, τ_X) is disconnected if and only if (X, τ_X) is j-disconnected.

Proof Let us take a topological space (X, τ_X) to be a disconnected space. Then





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$X = R \cup S$, where $\phi \in R$ and $\phi \in S$, such that R and S are separated sets. This implies, $cl(R) \cap S = \phi$ and $R \cap cl(S) = \phi$. Also $cl_j(R) \subseteq cl(R)$, which implies, $cl_j(R) \cap S \subseteq cl(R) \cap S = \phi$. Correspondingly, $R \cap cl_j(S) \subseteq R \cap cl(S) = \phi$. Thus R and S are j -separated sets such that $X = R \cup S$. Hence (X, τ_x) is j -disconnected.

Conversely, suppose (X, τ_x) is not j -disconnected. Then we have, $cl_j(R) \cap S \neq \phi$ or $R \cap cl_j(S) \neq \phi$, for any two j -open subsets R and S of (X, τ_x) . This implies $cl(R) \cap S \neq \phi$ or $R \cap cl(S) \neq \phi$. Thus (X, τ_x) is not disconnected.

Theorem 2.4. A topological space (X, τ_x) is j -disconnected if and only if there exists a proper subset $\phi = R$ of X is both j -closed and j -open.

Proof Suppose (X, τ_x) is j -disconnected space. Then $X = R \cup S$ where $\phi \neq R$ and $\phi = S$ are j -separated sets. i.e., $cl_j(R) \cap S = R \cap cl_j(S) = \phi$. This implies $R \cap S = \phi$ and $X = R \cup S$. Then $S = R^c$ and $R = S^c$. We have $cl_j(R) \cap S = \phi$ and $R \cap cl_j(S) = \phi \implies cl_j(R) \subseteq S^c = R$ and $cl_j(S) \subseteq R^c = S$. But we have, $R \not\subseteq cl_j(R)$ and $S \not\subseteq cl_j(S)$. Thus $R = cl_j(R)$ and $S = cl_j(S)$. Therefore, R and S are j -closed sets and also $R^c = S$, $S^c = R$ are j -open sets. Hence a non- empty proper subsets of X are both j -open and j -closed. Conversely, assume $\phi = R$ be a proper subset of X . Then there exist a subset S which is both j -open as well as j -closed and $R \cap S = \phi$. This implies $cl_j(R) = R$ and $cl_j(S) = S$. Now $cl_j(R) \cap S = R \cap cl_j(S) = \phi$. Thus R and S are j -separated such that $X = R \cup S$. Hence (X, τ_x) is j -disconnected space.

Remark 2.5. The following example shows that, every discrete space (X, τ_j) is

j -disconnected if the space contains atleast two elements.

Example 2.6. Let $X = \{q, r\}$. Then $\tau_x = \{\phi, \{q\}, \{r\}, X\}$, $\tau_j = \{\phi, \{q\}, \{r\}, X\}$ and $\tau^c = \{\phi, \{q\}, \{r\}, X\}$. Since $\phi = q$ is a proper subset of X which is both j -open and j -closed. Therefore (X, τ_j) is j -disconnected.

Theorem 2.7. If $\phi = R$ and $\phi = S$ are two j -separated subsets of a topological space (X, τ_j) then $R \cup S$ is also j -disconnected in (X, τ_j) .

Proof Let R and S be the j -separated subsets of (X, τ_j) . Then we have $\phi \neq R$, $\phi \neq S$, $R \cap cl_j(S) = \phi$, $cl_j(R) \cap S = \phi$ and $R \cap S = \phi$. Now, we consider $X - cl_j(R) = M_j$ and $X - cl_j(S) = N_j$. This implies $cl_j(R) \cap \phi$ and $cl_j(S) \cap \phi$, also $cl_j(R)$ and $cl_j(S)$ are j -closed subsets of $N(X, \tau_x)$. Therefore M_j and N_j are non-null j -open subsets of (X, τ_x) . But $(R \cup S) \cap M_j = (R \cup S) \cap (X - cl_j(R))$
 $= [R \cap (X - cl_j(R))] \cup [S \cap (X - cl_j(R))]$
 $= [R \cap S] \cup [S \cap S]$
 $= \phi \cup S$
 $= S$

In the same way, we get $(R \cup S) \cap N_j = R$. It shows that, there exist a sub- sets M_j and N_j in τ_j such that $(R \cup S) \cap M_j$ and $(R \cup S) \cap N_j$ are non-empty. $[(R \cup S) \cap M_j] \cap [(R \cup S) \cap N_j] = \phi$ and $[(R \cup S) \cap M_j] \cup [(R \cup S) \cap N_j] = \phi \cup R \cup S = X$. Then $M_j \cup N_j$ is the j -disconnectedness of $R \cup S$. Hence $R \cup S$ is j -disconnected.

Theorem 2.8. Let (X, τ_x) and (X, τ_j) be two topological spaces, R be non-empty subset of X and $M_j \cup N_j$ be j -disconnection of R . Then $R \cap M_j$ and $R \cap N_j$ are j -separated subsets of (X, τ_j) .

Proof Let $M_j \cup N_j$ be j -disconnection of R . Using our assumption and the definition of j -disconnected, there exist $M_j, N_j \in \tau_j$ such that $R \cap M_j = \phi$ and $R \cap N_j = \phi$ which implies $(R \cap M_j) \cap (R \cap N_j) = \phi$ and $(R \cap M_j) \cup (R \cap N_j) = R \cap [M_j \cup N_j] = R \cap R = R$. Now we prove, $cl_j(R \cap M_j) \cap (R \cap N_j) = \phi$ and $[R \cap M_j] \cap cl_j(R \cap N_j) = \phi$. Assume the contrary $cl_j(R \cap M_j) \cap (R \cap N_j) \neq \phi$. This implies $x \in cl_j(R \cap M_j)$, $x \in R$ and $x \in N_j \implies (R \cap M_j) \cap N_j \neq \phi \implies (R \cap M_j) \cap (R \cap N_j) \neq \phi$ which contradicts $(R \cap M_j) \cap (R \cap N_j) = \phi$. Thus $cl_j(R \cap M_j) \cap (R \cap N_j) = \phi$. Similarly $(R \cap M_j) \cap cl_j(R \cap N_j) = \phi$. Hence $R \cap M_j$ and $R \cap N_j$ are j -separated sets in $[X, \tau_j]$.





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Theorem 2.9. Let S be a subset of a topological space (X, τ_X) and (X, τ_X) be j -disconnected if and only if $S = R \cup S$ where R and S are j -separated sets.

Proof Assume $S = R \cup S$ where R and S are j -separated sets in (X, τ_X) . Therefore, $R \cup S$ is j -disconnected. Hence S is also j -disconnected.

Conversely, let S be j -disconnected. To prove R and S are two j -separated subsets of X such that $S = R \cup S$. By the definition of j -disconnected there exists a subsets M_j and N_j in τ_j such that $S \cap M_j \neq \phi$ and $S \cap N_j \neq \phi$. $(S \cap M_j) \cap (S \cap N_j) = \phi$ and $(S \cap M_j) \cup (S \cap N_j) = S$. Put $S \cap M_j = R$ and $S \cap N_j = S$. Hence R and S are two j -separated subsets of $(, \tau_X)$ such that $S = R \cup S$.

Extremally j -disconnected Spaces

Definition 3.1. A topological space (X, τ_X) is called extremally j -disconnected if $cl_j(R)$ is j -open for all $R \in JO(X)$.

Example 3.2. Let $X = \{q, r, s, t\}$ with $\tau_X = \{\phi, \{q\}, \{q, t\}, \{r, s\}, \{q, r, s\}, X\}$. Then $\tau^c = \{\phi, \{r, s, t\}, \{r, s\}, \{q, t\}, \{t\}, \phi\}$. For this topology, $\phi, X, \{q\}, \{r\}, \{s\}, \{q, r\}, \{q, s\}, \{q, t\}, \{r, s\}, \{q, r, s\}, \{q, r, t\}, \{q, s, t\}$ are the collection of pre-open sets. Therefore we have $\phi, X, \{q\}, \{q, t\}, \{r, s\}, \{r, st\}$ are the family of j -open sets. Here $cl_j\{q\} = \{q, t\}, cl_j\{q, t\} = \{q, t\}, cl_j\{r, s\} = \{r, s\}$ and $cl_j q, r, s =$. Therefore j -closure of every j -open set is j -open. Hence $(, \tau_X)$ is extremally j -disconnected.

Theorem 3.3. In general, the following statements are equivalent for any topological space (X, τ_X) .

(X, τ_X) is extremally j -disconnected.

$int_j(R_a)$ is j -closed for all j -closed set R_a in X .

$cl_j(R_a) \cup cl_j[X - cl_j(R_a)] = X$ for all j -closed set R_a in X .

$cl_j(R_a) \cup cl_j(R_b) = X$ for every pair of j -open sets R_a and R_b in (X, τ_X) with

$cl_j(R_a) \cup R_b = X$.

Proof (i) \implies (ii)

Let R be a j -closed subset of (X, τ_X) . To prove $int_j(R_a)$ is j -closed.

Put $X - int_j(R_a) = cl_j(X - R_a)$. Since R_a is j -closed and (X, τ_X) is extremally j -disconnected. Then $(X - R_a)$ is j -open and $cl_j(X - R_a)$ is j -open. This implies $(X - int_j(R_a))$ is j -open and $int_j(R_a)$ is j -closed.

(ii) \implies (iii)

Assume R_a is j -open subset of (X, τ_X) . Put

$X - cl_j(R_a) = int_j(X - R_a)$.

Then $cl_j(R_a) \cup cl_j(X - cl_j(R_a)) = cl_j(R) \cup cl_j(int_j(X - R_a))$

$= cl_j(R_a) \cup int_j(X - R_a)$

$= cl_j(R) \cup (X - cl_j(R)) = X$

(iii) \implies (iv)

Let R_a and R_b be two j -open subsets of (X, τ_X) such that

$$cl_j(R_a) \cup R_b = X. \tag{1}$$

$$\text{Using (iii) } cl_j(R_a) \cup cl_j(X - cl_j(R_a)) = cl_j(R_a) \cup R_b \tag{2}$$

$$\implies R_b = cl_j(X - cl_j(R_a)). \tag{3}$$

From (3), $R_b = X - cl_j(R_a)$.

$X - cl_j(R_a) = cl_j(X - cl_j(R_a))$

$\implies cl_j(R_b) = cl_j(X - cl_j(R_a))$

$\implies cl_j(R_a) = X - cl_j(R_a)$.

$cl_j(R_b) \cup cl_j(R_a) = X - cl_j(R_a) \cup cl_j(R_a)$

$= X$





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(iv) \implies (i)

Let R_a be any j-open subset of (X, τ_X) .

Take $R_b = X - cl_j(R_a) \implies cl_j(R_a) \cup R_b = X$.

Using (iv) we have $cl_j(R_a) \cup cl_j(R_b) = X$ and $cl_j(R_a)$ is j-open in (X, τ_X) . Hence (X, τ_X) is extremally j-disconnected.

Theorem 3.4. Let R_a and R_b be any two non-empty j-open subsets of (X, τ_X) and $R_a \cap R_b = \phi$. Then a topological space (X, τ_X) is extremally j-disconnected if and only if $cl_j(R_a) \cap cl_j(R_b) = \phi$ for every $R_a, R_b \in X$ such that $R_a \cap R_b = \phi$.

Proof Let $\phi = R_a$ and $\phi = R_b$ be two j-open subsets of extremally j-disconnected

space (X, τ_X) with $R_a \cap R_b = \phi$. $cl_j(R_a) \cap int_j(R_b) = cl_j(R_a) \cap R_b = \phi$. $int_j(cl_j(R_a)) \cap int_j(cl_j(R_b)) = \phi \implies cl_j(R_a) \cap cl_j(R_b) = \phi$.

Conversely, take G be an arbitrary j-open subset in (X, τ_X) . Then $X - G$ is j-closed set. This implies $int_j(G)$ is j-open set such that $G \cap int_j(G) = \phi$. By

hypothesis,

$$cl_j(G) \cap cl_j(int_j(X - G)) = \phi$$

$$\implies cl_j(G) \cap cl_j(X - cl_j(G)) = \phi$$

$$\implies cl_j(G) \subseteq int_j cl_j(G) \subseteq cl_j(G).$$

$$\implies cl_j(G) \cap [X - int_j cl_j(G)] = \phi.$$

$$cl_j(G) \subseteq int_j[cl_j(G)] \quad (4)$$

In general, $int_j(cl_j(G)) \subseteq cl_j(G)$

(5)

From (4) and (5), $cl_j(G) = int_j cl_j(G)$. Thus $cl_j(G)$ is j-open set in (X, τ_X) . Also G is arbitrary j-open set. Hence (X, τ_X) is extremally j-disconnected.

Theorem 3.5. In a topological space (X, τ_X) the following relations are equivalent.

(X, τ_X) is extremally j-disconnected.

For every j-open subsets of R_a and R_b in X such that

$$cl_j(R_a) \cap cl_j(R_b) = cl_j(R_a \cap R_b).$$

For every j-closed subsets S_a and S_b of X , $int_j(S_a) \cup int_j(S_b) = int_j(S_a \cup S_b)$.

Proof (i) \implies (ii)

Taking R_a and R_b as two non-empty j-open subsets of extremally j-disconnected space (X, τ_X) . We have $cl_j(R_a) \cap cl_j(R_b) = cl_j(R_a \cap R_b)$.

(ii) \implies (iii)

Take S_a and S_b are two j-closed subsets of extremally j-disconnected space (X, τ_X) .

Then $(X - S_a)$ and $(X - S_b)$ are j-open subsets. Therefore, we have

$$cl_j(X - S_a) \cap cl_j(X - S_b) = cl_j[(X - S_a) \cap (X - S_b)].$$

$$(X - int_j(S_a)) \cap (X - int_j(S_b)) = cl_j[X - (S_a \cup S_b)]$$

$$X - (int_j(S_a) \cup int_j(S_b)) = X - int_j(S_a \cup S_b).$$

Therefore, $int_j(S_a) \cup int_j(S_b) = int_j(S_a \cup S_b)$.

(iii) \implies (ii)

Proof is similar to (ii) \implies (iii).

(ii) \implies (i)

Let R_a be arbitrary j-open subset of (X, τ_X) . Then $X - R_a$ is j-closed. $cl_j(R_a) = int_j(cl_j(R_a))$. Therefore, we have $cl_j(R_a)$ is arbitrary j-open set in (X, τ_X) . Hence (X, τ_X) is extremally j-disconnected.

Theorem 3.6. If R_a and R_b are any two non-null j-open subsets of (X, τ_X) . Then (X, τ_X) is extremally j-disconnected if and only if

$$int_j(cl_j(R_a)) \cup int_j(cl_j(R_b)) = int_j(cl_j(R_a \cup R_b)) \text{ for all } R_a \text{ and } R_b \text{ in } X.$$

Proof Let (X, τ_X) be extremally j-disconnected space, R_a and R_b be arbitrary j-open subsets of (X, τ_X) . Therefore $cl_j(R_a)$ and $cl_j(R_b)$ are j-closed subsets of (X, τ_X) . Thus, $int_j(cl_j(R_a)) \cup int_j(cl_j(R_b)) = int_j(cl_j(R_a) \cup cl_j(R_b)) = int_j(cl_j(R_a \cup R_b))$.





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Conversely, Let M_a and M_b are two j -closed subsets of (X, τ_X) . Then $int_j(M_a)$ and $int_j(M_b)$ are j -open subsets of (X, τ_X) . By our assumption, $int_j(cl_j(int_j(M_a))) \cup int_j(cl_j(int_j(M_b))) = int_j(cl_j[int_j(M_a) \cup int_j(M_b)])$, since M_a and M_b are j -closed

subsets of (X, τ_X) . Therefore, we have

$$int_j[cl_j[int_j[cl_j(M_a)] \cup int_j[cl_j(M_b)]]] = int_j cl_j[int_j cl_j[M_a \cup M_b]] \\ = int_j cl_j[M_a \cup M_b]$$

Hence (X, τ_X) is extremally j -disconnected.

Theorem 3.7. If S_a and S_b are any two non null j -closed subsets of (X, τ_X) . Then (X, τ_X) is extremally j -disconnected if and only if $cl_j(int_j(S_a)) \cap cl_j(int_j(S_b)) = cl_j(int_j(S_a \cap S_b))$ for all S_a and S_b in (X, τ_X) .

Proof Assume (X, τ_X) is extremally j -disconnected and S_a, S_b are any two j -closed subsets of (X, τ_X) . Then $int_j(S_a)$ and $int_j(S_b)$ are j -open subsets of (X, τ_X) . Therefore, $cl_j(int_j(S_a)) \cap cl_j(int_j(S_b)) = cl_j(int_j(S_a) \cap int_j(S_b)) = cl_j int_j(S_a \cap S_b)$.

Conversely, let N_a and N_b be any two j -open subsets of (X, τ_X) .

Then $cl_j(N_a), cl_j(N_b)$ are j -closed subsets of (X, τ_X) . Now $cl_j(int_j(cl_j(N_a))) \cap cl_j(int_j(cl_j(N_b)))$

$$= cl_j int_j[cl_j(int_j(N_a))] \cap cl_j int_j[cl_j(int_j(N_b))]$$

$$= cl_j int_j(N_a) \cap cl_j int_j(N_b)$$

$$= cl_j int_j(N_a \cap N_b) = cl_j(N_a \cap N_b).$$

Hence (X, τ_X) is extremally j -disconnected.

CONCLUSION

This paper deals with the findings and observations of j -disconnectedness and extremally j -disconnectedness in topological spaces. We analyzed the characteristics of such spaces by suitable theorems and appropriate examples. Thus the study has proved that these concepts will be used in various areas of topological spaces.

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Power Quality Enhancement in Radial Distribution System by Harmonic Filters using Ant Lion Optimizer

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ABSTRACT

This present study was performed to evaluate the enzymic and non-enzymic antioxidant activities of *Momordica charantia* and *Trigonella foenumgraecum* seed extracts in diabetes induced rats. Diabetes Mellitus was induced by a single intraperitoneal injection of STZ-NIC and rats with blood glucose concentration more than 250mg/dl were used for the study. The ethyl acetate seed extracts of the plant samples were administered at doses of 200, 400 mg/kg b.w. and glibenclamide for 21 days and the activities of enzymic antioxidants superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) and non-enzymic antioxidants namely vitamin C, vitamin E and reduced glutathione (GSH) and lipid peroxidation were evaluated. There was a significant improvement in the activities and the levels of enzymic and non-enzymic antioxidants catalase, glutathione peroxidase, superoxide dismutase, vitamins C, E and reduced





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glutathione (GSH) and lipid peroxidation treatment with 400mg/kg b.w of the plant extracts and glibenclamide. This study demonstrates the antioxidant effect of the *Momordica charantia* and *Trigonella foenumgraecum* seed extracts that might help in control and prevention of diabetes mellitus.

Keywords: Diabetes, Enzymic antioxidants, Non-enzymic antioxidants, *Momordica charantia*, *Trigonella foenumgraecum*.

INTRODUCTION

Diabetes mellitus (DM) is a complicated, and non-contagious endocrine ailment that has posed clinical challenges globally, often linked with threats related to complicated metabolic development in patients. It is marked by elevated blood glucose and lipids and oxidative stress, which results in chronic complications involving diverse organs, mainly the kidneys, eyes, nerves, and blood vessels, among others, in the body. World Health Organization (WHO) has reported that DM is an outbreak prone to high malaise and death [1]. During hyperglycemia, production of reactive oxygen species and reactive nitrogen species increases. This results in decrease in the activity of antioxidant enzymes, induces oxidative stress in the body [2]. Reactive oxygen species (ROS) level elevation in Diabetes may be due to perturbations in antioxidant defense system. The variation in the levels of antioxidant enzymes makes the tissues susceptible to oxidative stress leading to the development of diabetic complications [3]. Antioxidants are biochemicals that can neutralize the potentially damaging action of free radicals such as unstable molecules as peroxyl radical, hydroxyl radical and singlet oxygen and peroxy nitrate radicals. Antioxidants either completely stop or significantly reduce the damaging effects of free radicals on cells. So, antioxidants and free radical studies are very important in today's research for understanding the relationships of diseases such as cancer, neurodegenerative diseases, Diabetes mellitus and cardiac arrest [4]. One of the great advantages of medicinal plants is that these are readily available and have fewer side effects for management of diabetes.

There are reports about 800 plants that may possess antidiabetic activities [5]. Antioxidants are present in all parts of plants like wood, bark, stems, pods, leaves, fruit, roots, flowers, pollen and seeds. The occurrence of such oxidative mechanisms in plants clarifies why a plenty of antioxidant compounds have been recognized in plant tissue. Plants mostly those with elevated levels of powerful antioxidant compounds have an essential role in the cure and treatment of illness concerning oxidative stress including Diabetes Mellitus [6]. *Momordica charantia* commonly known as bitter melon grows in tropical and subtropic areas, and is used as a food and medicine. It yields prickly fruit and lovely flowers. While bitter melon seeds, leaves, and vines have all been utilized for medicinal purposes, the fruit of the plant is the most widely used and safest part [7]. *Momordica charantia* seed extracts showed potent free radical scavenging activity, alpha- amylase inhibition and the mechanism were found to be noncompetitive inhibition. [8] *Trigonella foenum graecum* (Fenugreek) is a leguminous bean and which belongs to the family Fabaceae. The seeds and green leaves of *Trigonella foenum graecum* used as food possess many medicinal applications. Total fenugreek production in India was 113 thousand metric tonnes in the year 2012- 2013. In India; it is extensively used as ayurvedic medicine and in China as traditional medicine. Fenugreek is consumed in various parts of the world in different forms and has been regarded as a treatment for many ailments known to man [9]. Hence the present study was aimed to evaluate the *in vivo* antioxidant potential of *Momordica charantia* and *Trigonella foenumgraecum* seed extracts in Streptozotocin– Nicotinamide administered diabetes induced rats.

MATERIALS AND METHODS

Plant Collection, Identification and Preparation of Extract

Momordica charantia seeds (MCS) and *Trigonella foenum graecum* seeds (TGS) were dried, finely powdered, and stored in airtight containers at room temperature for further use. 5 grams of *Momordica charantia* seeds (MCS) and *Trigonella*



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foenum graecum seeds (TGS) powder were macerated with 50 ml ethyl acetate for 48 hours filtered and collected the solvent. The solvent was evaporated in water bath shaker to get dry extract and used for further analysis.

Experimental Animals

Adult male albino Wistar rats (6 weeks), weighing 150 to 200 g were used for the present antidiabetic study. The animals were housed in clean polypropylene cages and maintained in a well-ventilated temperature-controlled animal house with a constant 12-hour light/dark schedule. The animals were fed with standard rat pelleted diet and clean drinking water was made available *ad libitum*. All animal procedures were performed after approval from the Ethical Committee Clearance No: 53 IAE1012/c/17/CPCSEA-2013 and in accordance with the recommendations for the proper care and use of laboratory animals.

Acute toxicity studies

Acute oral toxicity study of *Momordica charanti* seeds (MCS) extract and *Trigonella foenum graecum* seeds (TGS) extract was studied in healthy rats (n= 3) according to guidelines set by Organisation for Economic Co-operation and Development (OECD). The plant extract was evaluated for the pharmacological potential in normal rats weighing 150 to 200 g. The animals were given 200 mg/kg of MCS and 2000 mg/kg of TGS initially, then 500, 1000, 1500, and 2000 mg/kg b.w., and their toxicity was assessed. For a full day, the animals were watched for signs of death. Further studies will be conducted using 1/5th and 1/10th of the highest dose (2000 mg/kg b.w.) as there was no mortality observed in the acute toxicity studies.

Induction of Diabetes Mellitus

The animals were kept overnight fasting and the initial fasting blood glucose was checked from tip of rat tail vein. Nicotinamide was dissolved in regular saline, and streptozotocin was dissolved in citrate buffer (pH 4.5). A single intraperitoneal injection of 60 mg/kg streptozotocin was given to overnight fasted rats 15 minutes after an i.p. injection of 120 mg/kg nicotinamide. This caused the rats to develop diabetes mellitus. Hyperglycemia was confirmed by the elevated levels of blood glucose determined after 72 hours. The animals with blood glucose concentration more than 250mg/dl were used for further study. The vehicle (saline), standard drug glibenclamide and plant extracts were administered to the respective group animals for 21 days. Throughout the study period glibenclamide and plant extracts were freshly dispersed in normal saline and distilled water before the administration.

Sample collection

At the end of the experimental period rats were fasted overnight and anaesthetized with diethyl ether (100ml/kg), blood samples were collected through retro-orbital sinus puncture with or without EDTA container for the estimation of selected biochemical and haematological parameters. The liver of the experimental rats was removed and a portion of each was stored at minus 40°C for performing the assays involving enzymic and non-enzymic antioxidants.

Determination of Enzymic antioxidants

The activities of enzymic antioxidants namely superoxide dismutase, catalase and glutathione peroxidase were determined in the liver of the control and experimental rats to assess the protection rendered by MCS, TGS and glibenclamide [10,11,12]

Determination of Non enzymic antioxidants

The activities of non-enzymic antioxidants vitamin C, vitamin E and reduced glutathione were determined in the liver of the control and experimental rats to assess the protection rendered by MCS, TGS and glibenclamide [13,14,15].



Ashokkumar Lakum *et al.*,**Determination of lipid peroxidation**

Hyperglycemia associated with hyperlipidemia could be the causative factor for the increased production of free radicals and lipid peroxides like malondialdehyde (MDA) [16]. Hence lipid peroxidation in experimental rats was estimated [17].

Statistical Analysis

The data were statistically analysed and statistical significance was determined by One-way Analysis of Variance (ANOVA) followed by Dunnett's multiple comparison test. A 'p' value of less than 0.05 was regarded as significant.

RESULTS AND DISCUSSION

An imbalance of oxidant and antioxidant defence systems result in alterations in the activity of antioxidant enzymes such as superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx). In the present study, the activity of superoxide dismutase, catalase and glutathione peroxidase in normal and Diabetes induced rats were evaluated. The results of antioxidant activity of enzymes on control and experimental rats are depicted in Figures 1 a, 1b and 1c. There was a significant decrease ($p < 0.05$) in the activity of enzymic antioxidants namely superoxide dismutase, catalase and glutathione peroxidase in the liver of diabetic control rats. In diabetic rats treated with glibenclamide and plant extracts, there was a significant improvement ($p < 0.05$) in the activity of these enzymes. The activity of these enzymes in rats treated with highest dose of 400mg/kg b.w of MCS was comparable to the activity of enzymes in glibenclamide treated rats. Oxidative stress is a condition of reduction in anti-oxidative enzyme activities of SOD, CAT and GPx. The antioxidant enzymes SOD and CAT play an important role in reducing cellular stress. While CAT reduces hydrogen peroxides and shields higher tissues from extremely reactive hydroxyl radicals, SOD scavenges the superoxide radical by converting it to hydrogen peroxide and molecular oxygen [18].

The decreased activities of CAT and SOD may be response for increased production of H_2O_2 and O_2 by the auto-oxidation of glucose. Because these enzymes accelerate the dismutation of oxygen radicals and remove organic peroxides and hydroperoxides produced by unintentional exposure to STZ, they are crucial for maintaining physiological levels of oxygen and hydrogen peroxide. [19]. Treatment with MCS and TGS seemed to increase the activity of these enzymes and might help to control free radicals when compared to Glutathione peroxidase enzyme is relatively stable, but it has been reported that is disabled in severe oxidative stress conditions. *Citrullus lanatus* (watermelon) treated diabetic rats showed an increase in the activity of Gpx status which was almost close to the control level and this is remarkable as this implies that the juice could have an ameliorating effect on the altered antioxidant status of diabetic rats [20]. The activities of antioxidant enzymes SOD and CAT were significantly increased after the treatment of ethyl acetate fraction of ethanol extract of *Stereospermum suaveolens* in STZ-induced diabetic rats indicating the free radical scavenging activity and their protective effect against diabetic kidney cellular damage [21]. Treatment with root extracts of *Premnacorymbosa* (Rottl.) increased the activity of antioxidant enzymes SOD, CAT and GPx when compared to diabetic rats. The effect produced by plant extract was comparable with that of standard drug glibenclamide [22].

Non enzymic antioxidants

The changes in the levels of non-enzymic antioxidants namely vitamin C, vitamin E and reduced glutathione (GSH) are important in cellular system in curtailing reactive oxygen species. The levels of these non – enzymic antioxidants in control, diabetic and treated rats were assessed and the results are depicted in Figures 2 a, 2 b and 2 c. There was a significant reduction ($p < 0.05$) in the nonenzymic antioxidants namely vitamins C, E and reduced glutathione (GSH) in diabetic rats when compared to control rats. The levels of these antioxidants were significantly increased ($p < 0.05$) in rats by treating with glibenclamide, MCS and TGS ethyl acetate extracts. The levels of vitamin C, E and reduced glutathione were found to be increased significantly ($p < 0.05$) on treatment with 400mg /kg b.w. Vitamin C is an effective antioxidant in various biological systems [23]. Vitamin C plays a central role in the antioxidant protective system, protecting all lipids undergoing oxidation and diminishing the number of apoptotic cells [24]. Vitamin E acts





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as a non-enzymatic antioxidant and reduces chain reactions of lipid peroxidation [25]. Vitamin E shields cell structures from damage by reducing lipid hydroperoxides produced during the peroxidation process. The decreased level of vitamin E found in the liver of diabetic rats as compared with control rats could be due to increased oxidative stress, which accompanies the decrease in the level of antioxidant and might be related to the cause of Diabetes Mellitus [26]. Enhanced level of vitamin E or tocopherols in plant extract treated groups is based on their ability to donate phenolic hydrogens to lipid radicals. Vitamin E protects poly unsaturated fatty acids from being oxidized [27]. Decreased levels of nonenzymatic antioxidant vitamin C and E in diabetic rats, when compared to those of control rats. The levels of these antioxidants were significantly increased in different organs (liver, kidney, brain, heart and pancreas) of diabetic rats by treatment with root extracts of *Premnacorymbosa* (Rottl) [28]. GSH has a multifaceted role in anti-oxidant defence. It is a direct scavenger of free radicals as well as a co-substrate for peroxide detoxification by glutathione peroxidase [29]. Hyperglycemia is found to be an indirect cause of GSH depletion. As GSH is an important antioxidant molecule, its depletion leads to an increase of oxidative stress [30]. Oral administration of aqueous fruit extract of *Passiflora ligularis* for 30 days showed significant elevation in all the non-enzymatic antioxidants values and reached near normal values. This can reduce the oxidative stress leading to less degradation of GSH due to less production of ROS in diabetic stage [31]. In the present study, there was an increased level ($p < 0.05$) of reduced glutathione in MCS and TGS treated groups which imply that the plant extracts might have an enhanced amount of GSH activity which plays a role in coordinating the body's antioxidant defense processes. Reduced glutathione, synthesized mainly in the liver is an important non-enzymic antioxidant in the antioxidant defense system.

Lipid peroxidation

The status of lipid peroxidation of control and experimental rats were studied and the results are depicted in Figure 3. Lipid peroxidation was increased significantly ($p < 0.05$) in diabetic rats as compared to that of control rats. The rats treated with glibenclamide, MCS and TGS showed significant reduction ($p < 0.05$) in lipid peroxidation. The diabetic rats treated with highest dose of 400mg/kg b.w showed significant improvement ($p < 0.05$) in antioxidant activity and the reduction in malondialdehyde production was comparable to glibenclamide treated rats. Lipid peroxidation is an autocatalytic free radical process formed by oxidative damage of cells. ROS produced in tissues results in lipid peroxidation and subsequently enhances the levels of malondialdehyde which is the major end product and index of lipid peroxidation [32]. Polyunsaturated lipids oxidatively deteriorate due to a process called lipid peroxidation, which is mediated by free radicals. The increase in oxygen free radicals in Diabetes could be primarily due to increase in blood glucose levels, which upon auto-oxidation generates free radicals [33]. *Coleus vettiveroides* Jacob extracts possess potent antioxidant and lipid peroxidation activities and can be employed in protecting tissue from the oxidative stress, which might be responsible for its hypoglycemic property [34]. In the present study, increased lipid peroxidation in STZ-induced diabetic rats might be due to an increase in the generation of free radicals by STZ. The ability of MCS and TGS extracts to quench hydroxyl radicals seems to be directly related to inhibiting the process of lipid peroxidation. After oral administration of the plant extracts for 21 days the elevated values restored back to near normal level. Lipid peroxidation significantly decreased in the treated groups, indicating that it plays a protective role against lipid peroxidation.

CONCLUSION

In the present study *in vivo* antioxidant activities of *Momordica charantia* and *Trigonella foenumgraecum* seed extracts in streptozotocin–nicotinamide administered diabetes induced rats showed a significant improvement in the activities and the levels of enzymic and non-enzymic antioxidants catalase, glutathione peroxidase, superoxide dismutase, vitamins C, E and reduced glutathione (GSH) on treatment with plant extracts. The rats treated with MCS and TGS also showed significant reduction in lipid peroxidation. The various antioxidant activities exhibited by *Momordica charantia* and *Trigonella foenumgraecum* may be attributed to their effectiveness as good scavengers of free radicals. Hence, these might be useful in the control of hyperglycaemia and due to its potent antioxidant properties may help in prevention of complications in diabetes.





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CONFLICTS OF INTEREST

The author declares that there are no conflicts of interest

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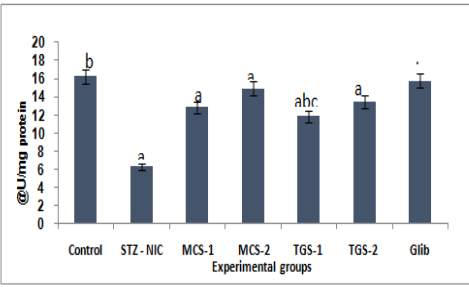
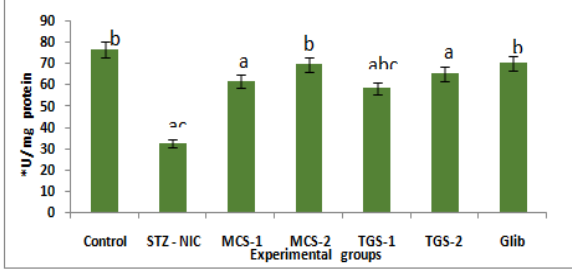
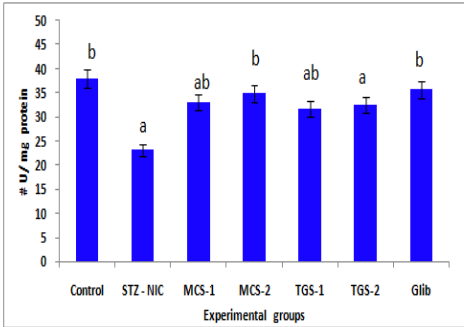
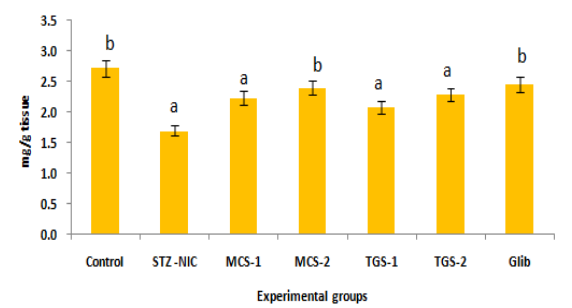
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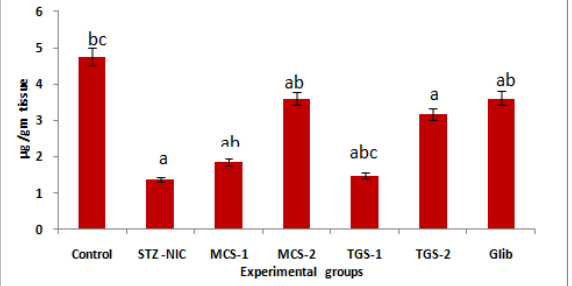
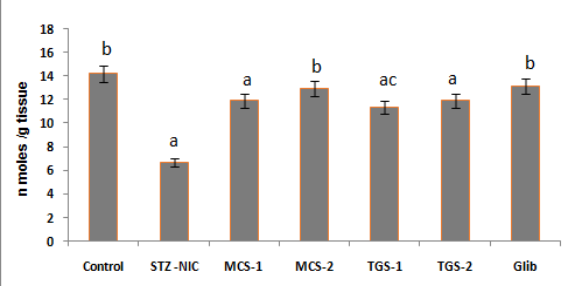
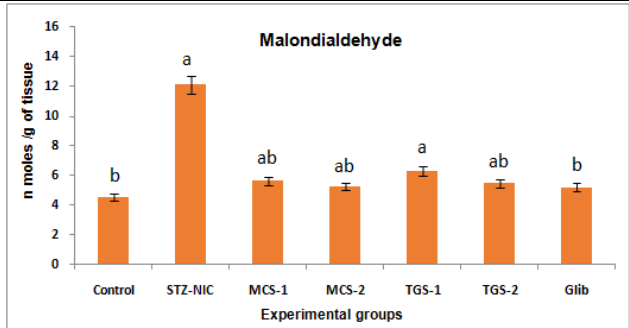
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<p>Values are mean± SEM (n= 6) @ 1 Unit: Amount of enzyme that causes 50% reduction in NBT oxidation a-p <0.05 compared with control group b-p <0.05 compared with STZ –NIC group c-p <0.05 compared with Glib (200µg/kg b.w) treated group (One way ANOVA followed by Dunnett’s multiple Comparison test) MCS -1: 200mg/kg b.w, MCS-2:400mg/kg b.w, TGS -1: 200mg/kg b.w, TGS 2:400mg/kg b.w. Figure 1a: Activity of hepatic superoxide dismutase in the experimental rats</p>	<p>Values are mean± SEM (n= 6) *1 Unit: Amount of enzyme required to decrease the absorbance at 240nm by 0.05 units a-p <0.05 compared with control group b-p <0.05 compared with STZ –NIC group c-p <0.05 compared with Glib (200µg/kg b.w) treated group (One way ANOVA followed by Dunnett’s multiple Comparison test) MCS -1: 200mg/kg b.w, MCS-2:400mg/kg b.w, TGS -1: 200mg/kg b.w, TGS -2:400mg/kg b.w. Figure 1b: Activity of hepatic catalase in the experimental rats</p>
	
<p>Values are mean± SEM (n= 6) # 1 Unit: µ moles of GSH consumed/minute//mg liver protein. a-p <0.05 compared with control group b-p <0.05 compared with STZ –NIC group c-p <0.05 compared with Glib (200µg/kg b.w) treated group (One way ANOVA followed by Dunnett’s multiple Comparison test) MCS -1: 200mg/kg b.w, MCS-2:400mg/kg b.w, TGS -1: 200mg/kg b.w, TGS -2:400mg/kg b.w. Fig 1c Activity of hepatic glutathione peroxidase in the experimental rats</p>	<p>Values are mean± SEM (n= 6) a-p <0.05 compared with control group b-p <0.05 compared with STZ –NIC group c-p <0.05 compared with Glib (200µg/kg b.w) treated group (One way ANOVA followed by Dunnett’s multiple Comparison test) MCS -1:200mg/kg b.w, MCS-2:400mg/kg b.w, TGS -1: 200mg/kg b.w, TGS -2:400mg/kg b.w. Figure 2a Levels of hepatic vitamin C in the experimental rats</p>





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<p>Values are mean± SEM (n= 6) a-p <0.05 compared with control group b-p <0.05 compared with STZ –NIC group c-p <0.05 compared with Glib (200µg/kg) treated group (One way ANOVA followed by Dunnett’s multiple Comparison test) MCS -1: 200mg/kg b.w, MCS-2:400mg/kg b.w, TGS -1: 200mg/kg b.w, TGS -2:400mg/kg b.w. Figure 2b Levels of hepatic vitamin E in the experimental rats</p>	<p>Values are mean± SEM (n= 6) a-p <0.05 compared with control group b-p <0.05 compared with STZ –NIC group c-p <0.05 compared with Glib (200µg/kg b.w) treated group (One way ANOVA followed by Dunnett’s multiple Comparison test) MCS -1: 200mg/kg b.w, MCS-2:400mg/kg b.w, TGS -1: 200mg/kg b.w, TGS 2:400mg/kg b.w. Figure 2 c Levels of hepatic reduced glutathione in the experimental rats</p>
	
<p>Values are mean± SEM (n= 6) a-p <0.05 compared with control group b-p <0.05 compared with STZ –NIC group c-p <0.05 compared with Glib (200µg/kg b.w) treated group (One way ANOVA followed by Dunnett’s multiple Comparison test) MCS -1: 200mg/kg b.w, MCS-2:400mg/ kgb.w, TGS -1: 200mg/kg b.w, TGS -2:400mg/kg b.w. Figure 3 Lipid peroxidation in the liver of experimental rats</p>	





Effective Decolorization and Detoxification of Disperse Dyes using Newly Isolated Bacterial Strains

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ABSTRACT

A number of bacterial cultures were isolated from various sources and tested for their potential to detoxify and decolorize the disperse dyes present in the textile effluent. Out of twenty-two, three strains—*Fictibacillusgelatini*, *Bacillus subtilis subsp. inaquosorum*, and *Bacillus subtilis subsp. subtilis*—displayed exceptional capability for disperse dye decolorization. Enzyme profiling revealed effective production of laccase and azoreductase. A variety of synthetic dyes were selected for experimentation and all the strains showed 100% decolorization at optimum conditions including carbon sources (maltose, starch, mannitol and glucose), nitrogen supplies (yeast extract, ammonium nitrate, beef extract and peptone), pH (6.0- 9.0), temperature (30°C, 37°C and 40°C), inoculum size (3%, 5% and 7.5%), and dye concentrations upto 500 ppm. Microbial consortia of these three isolates resulted in complete decolorization of all the dyes at optimum conditions. These isolates significantly reduced the pH (28%), COD (49%), TDS (51%), and TSS (86%) levels in addition to removing the colors from these effluents.

Keywords: bacterial isolates, consortia, decolorization, disperse dyes, effluents

INTRODUCTION

The demand for synthetic dyes in the Indian textile industries has significantly expanded during the past decade. Due to scarcity and high cost of natural dyes, textile industry has to look for other more cost-effective, readily



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accessible dyes. Out of an annual production of about 7×10^7 tonnes, the textile sector uses about 10,000 tonnes of synthetic dyes per year [1]. Improper disposal of waste water by textile industries is one of the major challenges currently affecting the entire planet. These artificial dyes travel over long distances together with the wastewater [2] and persist in the soil and water for an extended period of time. It decreases the amount of dissolved oxygen in water bodies and prevents photosynthetic activity, which contributes to the rise in biological and chemical oxygen demand and eventually has an impact on health of aquatic life and habitats. Additionally, it alters microbial populations and raises soil salinity, causing soil contamination [3,4,5]. Many researchers have investigated the cytotoxic and genotoxic effects of synthetic dyes [6]. Synthetic textile dyes containing polycyclic, triphenylmethane and anthraquinone causes nuclear defects, liver cancer, urothelial carcinoma, spleen cancer and chromosomal abnormalities in human cells [7]. Disperse dyes are non-ionic dyes, toxic to store and difficult to degrade [8]. Synthetic textile dyes are stable and difficult to degrade due to their complex aromatic structure and often created to be resistant to fading from light, oxidising agents, and chemicals [9]. As a result, existing conventional physico-chemical processes for decolorizing dye effluent are costly and not very effective. These methods are economically unfeasible and generate toxic by-products as sludge [10, 11]. Textile effluents have been reported to be treated using ion exchange [12], adsorption [13], chemical coagulation [14], oxidative remediation [15], photo-degradation [16] and membrane treatment technologies including microfiltration, electrodialysis, nanofiltration, reverse osmosis, and ultrafiltration. However, these techniques are costly and could result in undesired byproducts [17]. Therefore, in order to reduce the risk of water contamination, it is necessary to create environmentally safe and commercially feasible technologies for treating synthetic dyes in textile effluents. Researchers have investigated the ability of microbes, such as bacteria, yeast cells, fungal species, and algal species to decolorize and breakdown resistant textile dyes and mineralize to produce water and carbon dioxide. Biological approaches, however, have cheap operating costs and consistent results; are ecofriendly and do not generate a lot of sludge [18]. Numerous bacterial strains including *Bacillus subtilis*, *Paenochrobactrumglaciei*, *Brevibacilluspanacihumi*, *Bacillus cereus*, *Bacillus sphaericus*, *Paenibacilluspocheonensis* and *Escherichia coli* were found to be effective decolorizers of a wide range of disperse dyes [19]. Therefore, the present study is mainly focused on the isolation of potent bacterial cultures for the effective treatment of waste discharge of textile industries containing disperse dyes. The current study's objective was to identify and characterize effective bacterial strains having remarkable capacity to decolorize or degrade different types of disperse dyes. It was planned to use isolated bacteria, either by themselves or in a consortium, to create effective biological processes to facilitate the treatment of discharges containing various dyes.

MATERIALS AND METHODS

Dyes and Chemicals

Different Disperse dyes (Disperse red 1, Disperse orange 1, Disperse orange 30, Disperse blue 79, Disperse red 167, Disperse blue 183, Disperse yellow 198) were procured from Textile Mill, Bhiwani, Haryana, India. Analytical grade chemicals were acquired from Hi-Media Laboratories, India.

Isolation, screening and preservation of bacterial cultures

The following samples were taken from Nahar Textile Industry, Lalru, Punjab: soil, wet sludge, dry sludge, and effluent of disperse dyes. The samples were stored at room temperature in sterile vials, and experiments were performed within 24 hours after collection. 1% of the collected samples were aseptically inoculated in nutrient broth containing 500 mg/L each of the three dyes in a 250 mL Erlenmeyer flask. Dilution tubes were made from the enriched culture after 24 hours of incubation at 37°C under aerobic conditions. Using spread plate and streak plate methods, pure colonies were isolated and their potency to decolorize the dye (500mg/L) was tested. The highest decolorizing colonies were chosen for additional studies. The pure single-colony cultures were kept at -20°C in 15% glycerol for storage. A number of bacterial cultures like *Brevibacilluslaterosporus*, *Enterobacter gergoviae* etc [20]. have been identified by other workers that have ability to degrade disperse dyes.



**Rashmi et al.,****Biochemical and morphological identification of bacterial cultures**

Morphological and biochemical tests were performed for identification of bacterial cultures. Gram's staining technique was used for morphological characterization. Further identification of bacterial cultures was done by MTCC, IMTECH, Chandigarh using 16 S r-DNA sequencing.

Effect of pH and temperature

To evaluate the impact of pH, 500 mg/L of each dye was mixed in modified ZZ media individually and kept at different pH values- pH 6.0, 7.0, 8.0, 9.0. The flasks were inoculated with 5 or 10% v/v of bacterial cultures and incubated at 37 °C. The effect of temperature was investigated by inoculating overnight bacterial cultures in the modified ZZ medium and incubating them at 25°C, 30°C, 37°C, 40°C, and 50°C and pH of the medium was maintained at 7.0.

Effect of nitrogen and carbon source

Different sources were studied to evaluate the effect of nitrogen and carbon source. Glucose, galactose, fructose, mannitol, maltose, sucrose & starch were used as carbon sources. For nitrogen sources, ammonium nitrate, peptone, malt extract, yeast extract, beef extract and sodium nitrate were used at a concentration of 5g/L. These sources were added individually to modified ZZ media. The overnight growing bacterial culture was added to the flasks at concentration of 5 or 10% v/v, and incubated at a temperature of 37°C.

Enzyme screening assays: Quantitative assay

For interpretation, quantitative findings are presented numerically and compared with the related reference period. The activities of enzymes- laccase, azo-reductase, tyrosinase, and lignin peroxidase (LiP) were examined in cell free extracts and culture supernatants.

Laccase assay (EC. 1.10.3.2)

Laccase assay (EC. 1.10.3.2) was performed by a modified protocol of Zarvazina et al. (2004) which used 2, 2'-azino-bis-(3-ethylthiazoline-6-sulfonate) (ABTS) as a substrate at pH 6.0. To start the reaction, 1 ml of the sample was added, which was then spectrophotometrically monitored at 436 nm. A unit of activity was defined as the total amount of enzyme necessary to convert 1 μ M ABTS per minute per ml. Laccase assay was also done by using guaicol as a substrate at pH 6.5 and was measured spectrophotometrically at 465 nm [21]. The amount of enzyme needed to raise absorbance by 0.001 units at 37°C was defined as one unit.

Azoreductase assay (EC. 1.7.1.6)

Azoreductase assay was performed using the procedure, which included 4.45 M of dyes, 50 mM phosphate buffer (pH 7.4) containing 100 μ M NADH and 1 ml of enzyme solution and change in color absorbance (430 nm) was observed at room temperature [22].

Tyrosinase

Tyrosinase assay was done by using a reaction mixture of 2 ml including 0.1M phosphate buffer (pH 7.4) with 0.01% catechol [23].

Lignin peroxidase (LiP)

To measure the activity of lignin peroxidase, a reaction was carried out using 2.5 ml of mixture containing 100 mM n-propanol, 50 mM tartaric acid and 10 mM H₂O₂ and the presence of propanaldehyde at 300 nm was monitored [24]. One unit of enzyme activity was described as the change in absorbance unit/min/mg of enzyme against blank test tube that included all the constituents other than the enzyme solution. All enzyme experiments were performed in triplicates, and the average results were determined. Protein content was estimated by Lowry's method [25].





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Decolorization Assay

All decolorization tests were carried out in a 250 ml Erlenmeyer flask comprising 100 ml of pre-enriched bacterial culture in modified ZZ media. At regular interval of 12 hours, the samples (2ml) were taken out of the test and control media, and centrifuged at 10,000 rpm for 10 minutes to eliminate the cellular debris. Decolorization of dyes was assessed spectrophotometrically at the corresponding λ max of dye, and the results were compared with uninoculated medium containing 500mg/l of dye, taken as control. All the experiments were performed in triplicates. Decolorization efficacy of bacterial cultures was calculated by the given equation [26]:

$$\text{Decolorization (\%)} = \frac{A^0 - A}{A^0} \times 100$$

A^0 = absorbance before decolorization

A = absorbance after decolorization

Development of consortia

Three bacterial isolates identified as *Fictibacillusgelatini*, *Bacillus subtilis* subsp. *inaquosorum* and *Bacillus subtilis* subsp. *subtilis*, having greatest decolorization potential were utilized for consortium development.

Textile effluent and their physico- chemical analysis after treatment

The samples of effluents (L1, L2, and B1, B2) were collected from Nahar textile industry, Lalru, Punjab and Bhiwani textile mill, Haryana respectively. They were purple (L1), brown (L2), dark green (B1) and dark brown (B2) colored and smelled strongly. The effluents were treated with bacterial consortia and tested for their physiological characteristics like pH, color, total suspended solid (TSS), total dissolved solid (TDS), chemical oxygen demand (COD) before treatment and after treatment.

RESULTS

Screening and Isolation of bacterial cultures

Using an enrichment approach, twenty-two distinct types of bacterial strains were isolated. Out of which, three strains showed highest decolorization of dyes in minimum duration during screening protocol.

Biochemical, morphological characterization of bacterial strains and their molecular identification

Three most effective isolates which can decolorize the disperse dyes, were found to be rod shaped, present singly or in chains and gram positive. On the basis of their morphological, biochemical characterization and 16 S-rDNA analysis, they were recognized as *Fictibacillusgelatini*, *Bacillus subtilis* subsp. *inaquosorum* and *Bacillus subtilis* subsp. *subtilis* by MTCC IMTECH Chandigarh.

Analysis of dye spectrum

The percent dye decolorization by the strains was studied using an analytical approach. A spectrophotometric analysis was used to measure the absorbance of the supernatant withdrawn at appropriate time intervals for the dyes: DO 1 (483 nm), DY 198 (390 nm–520 nm), DR 167 (390 nm–520 nm), DO 30 (390 nm–520 nm), DB 183 (200 nm–800 nm), and DR 1 (502 nm) in the visible spectrum. Following that, the percentage of decolorization was computed using the difference between the initial and final absorbance values [29].

Enzyme profiling and activity calculation

In order to profile the enzymes secreted by bacterial cultures, various quantitative and qualitative assays were conducted for laccase, azoreductase, tyrosinase and lignin peroxidase. Enzymes- laccases and azo reductases have been found to be the most promising for bio-remediation of disperse dyes. Isolates *Fictibacillusgelatini* and *Bacillus subtilis inaquosorum* showed the highest enzymatic activity of laccase and azoreductase respectively, with low activities of LiP and tyrosinase. On the other hand, the isolate *Bacillus subtilis subtilis* showed highest enzyme activity of azoreductase and least of laccase, tyrosinase and LiP (Table 1).





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Parametric optimization

By adjusting one parameter at a time, the optimization of various parameters was done in order to achieve an effective decolorization of disperse dyes. For desirable dye decolorization activity, each bacterial strain has its own unique set of requirements.

Effect of pH

Isolate *Fictibacillusgelatini* showed complete decolorization of DO 1 and DR 167 within 18 hours and all other dyes within 2 days at pH 7.0. At pH 8.0 and 9.0, complete decolorization of DO 1, DY 198, DO 30, DB 79 dyes was achieved between 1 to 8 days whereas decolorization was reduced by 20% for DR 167, 12% for DR 1 and 100% for DB 183 at pH 8.0. At pH 10, only three dyes, DO 1, DR 167 and DB 79 showed complete decolorization and 30% decolorization was observed for DY 198 while no decolorization of other dyes was found. At pH 6.0, there was no decolorization of dyes except for DO 30 which showed only 20% decolorization (Table 2). At pH 7.0, isolate *Bacillus subtilis inaquosorum* showed complete decolorization of all the dyes between 18 h to 8 days except DR 167 which showed 45% decolorization after 8 days and dye DB 183 that showed no decolorization. At pH 6.0, only two dyes, DO 1 and DB 79 were completely decolorized between 1 to 2 days and 50% decolorization was found in case of DO 30 after 4 days (Table 3). At pH 7.0, isolate *Bacillus subtilis subtilis* showed complete decolorization of all the dyes between 18 h to 8 days except DB 183 that showed 53% decolorization after 8 days. At pH 6.0, DO 1 and DB 79 showed complete decolorization in 2 to 4 days and DR 167 showed 84% decolorization in 4 days (Table 4).

Effect of temperature

Isolate *Fictibacillusgelatini* showed complete decolorization of all the dyes at 37°C between 18 h to 8 days. At temperature 30°C, dye DR 1 was completely decolorized while DR 167 was 89% decolorized. At 40°C and 45°C, two dyes, DO 30 and DR 1 were 100% decolorized while DO 1 was decolorized up to 86% and 75% at these temperatures respectively, between 2 to 4 days (Table 2). *Bacillus subtilis inaquosorum* showed significant decolorization of disperse dyes at temperatures 37°C and 40°C. Total decolorization of all the dyes was noticed at 37 °C between 18 h to 8 days except DR 167 which showed 45% decolorization after 8 days and DB 183 which showed no decolorization. At 40°C, 100% decolorization of dyes DR 167, DO 30 and DR 1 was obtained between 2 to 3 days whereas DO 1, DY 198 and DB 79 showed 89%, 85% and 96% decolorization respectively and no decolorization was noticed in case of dye DB 183. At 30 °C, DR 1 and DB 79 showed 100% and 89% decolorization respectively, after 3 days. At 45°C, DO 30 and DR 1 showed 100% decolorization while DO 1 and DY 198 showed 67% and 82% decolorization, respectively, after 3 days. At 50°C, dye DO 1 showed 62% decolorization after 3 days (Table 3). Isolate *Bacillus subtilis subtilis* showed complete decolorization of total dyes at temperature 37°C and 40°C between 18 h to 8 days except DB 183 which showed 56% decolorization at 37°C after 8 days and no decolorization was observed at 40°C. At 30°C, DB 183, DB 79 and DR 1 showed 100% decolorization between 3 to 4 days and DY 198 showed 46% decolorization after 3 days. At 45°C, dyes DO 30, DB 79 and DR 1 showed 100% decolorization. At temperature 50°C, DR 167 and DB 79 showed 100% and 88% decolorization, respectively, after 3 days (Table 4).

Effect of Inoculum size

Different levels of decolorization were achieved using different inoculum sizes. Isolate *Fictibacillusgelatini* completely decolorized all the dyes with 10% inoculum size between time period of 18 h to 2 days. At inoculum size 7.5 %, decolorization of all the dyes were obtained between 1 to 8 days except DB 183 which showed no decolorization and DO 30 which showed 85% decolorization after 2 days. Inoculum size 3% resulted in complete decolorization of DO 1, DR 167 and DB 79 between 3 to 7 days while 67% decolorization was observed in case of DO 30 after 7 days. In case of inoculum size 5%, complete decolorization of dyes DO 1, DR 167, DO 30 and DB 79 were obtained after 3 to 4 days while 58% decolorization was observed in case of DR 1 after 6 days. Least decolorization was observed using 1% inoculum which showed complete decolorization of DO 1 and DB 79, between 3 to 4 days and 56% decolorization of DO 30 after 6 days (Table 2). With 10% inoculum size, *Bacillus subtilis inaquosorum* showed complete decolorization of DO 1, DO 30, DB 79 and DR 1 between 10 h to 2 days with 86% and 98% decolorization of DY 197 and DR 167, respectively, between 6 to 8 days. Inoculum size 7.5 % resulted in complete decolorization of dyes DO 1, DR 167 and DO 30 between 18 h to 2 days while 83% decolorization was noticed in case of DY 198, after 8 days. Least

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decolorization was observed at inoculum size 1% and 3%, which resulted in complete decolorization of only a single dye-DO 1 after 3 days. In case of inoculum size 5%, complete decolorization of DO 1 was observed after 3 days while 45% and 50% decolorization was noticed in case of dyes, DR167 and DO 30, respectively (Table 3). At inoculum size 5%, isolate *Bacillus subtilis subtilis* completely decolorized all the dyes between 18 h to 8 days except DB 183 which showed 56% decolorization after 8 days. At inoculum size 7.5%, dyes DO 1 and DY 198 were completely decolorized between 2 to 7 days while 60% decolorization was observed in case of DO 30 after 6 days. Inoculum size 10% resulted in complete decolorization of DO 1 after 4 days and 56% decolorization of DO 30 after 6 days. Least decolorization was observed in case of inoculum size 1% which resulted in 79% decolorization of DO 1 after 2 days. Inoculum size 3% resulted in complete decolorization of DY 198 and DR167 between 1 to 8 days (Table 4).

Effect of different concentration of dyes

Isolate *Fictibacillusgelatini* showed complete decolorization of all the dyes at 100ppm, 200ppm and 500ppm between 18 h to 8 days while DO 30 was decolorized upto 78% after 5 days at 1000ppm (Table 2). Isolate *Bacillus subtilis inaquosorum* also showed complete decolorization of all the dyes at 100ppm and 200ppm between 12 h to 8 days. At 500ppm, complete decolorization of dyes DO 1, DO 30, DB 79 and DR 1 were observed between 18h to 2 days while DY 198 and DR167 showed 86% and 98% decolorization, respectively, between 6 to 8 days. At 1000ppm, 49% and 84% decolorization were observed in case of DO 30 and DB 79, respectively, between 3 to 4 days (Table 3).

Isolate *Bacillus subtilis subtilis* showed complete decolorization of all the dyes at 100ppm and 200ppm within 12 h to 4 days while at 500 ppm, all dyes were completely decolorized between 18 h to 8 days except dye DB 183 which resulted in 56% decolorization after 8 days. At 1000ppm, 62% and 40% decolorization were observed in case of DR 167 and DO 30, respectively, between 3 to 4 days (Table 4).

Effect of nitrogen source

The accessibility of nutrients determines the growth of microorganisms which highly influence the decolorization of dyes. Different nitrogen sources resulted in different levels of decolorization. Isolate *Fictibacillusgelatini* showed complete decolorization of all the dyes in presence of yeast extract as nitrogen source between 18 h to 8 days and least decolorization was observed in presence of sodium nitrate which resulted in 100% and 42% decolorization of DO 1 and DY 198 respectively between 3 to 8 days. Using peptone as nitrogen source resulted in complete decolorization of DO 1 and DR 167 between 3 to 4 days while 35% and 87% decolorization were observed in case of DO 30 and DB 79, respectively, between 6 to 8 days. In case of malt extract, complete decolorization of dye DO 1 was observed after 2 days while 38%, 59%, 85% and 48% decolorization were obtained in case of DO 30, DB 183, DB 79 and DR 1, respectively, between 5 to 8 days. Beef extract as nitrogen source resulted in complete decolorization of DO 1 and DR 1 between 2 to 5 days while 17%, 20% and 80% decolorization were noticed in case of DO 30, DB 183 and DB 79, respectively, between 6 to 8 days. Utilizing ammonium nitrate as nitrogen source resulted in complete decolorization of DR 167 and DR 1 after 2 days while 82% and 98% decolorization were found in case of DO 1 and DO 30, respectively, between 3 to 4 days (Fig. 1). Isolate *Bacillus subtilis inaquosorum* showed complete decolorization of dyes in presence of yeast extract between 18 h to 8 days except DB 183 which resulted in no decolorization and DR 167 which showed 45% decolorization after 8 days. Complete (100%) decolorization of all the dyes were observed in presence of ammonium nitrate between 3 to 5 days except DY 198 and DB 183 which showed no decolorization. Least decolorization was observed in case of sodium nitrate which showed complete decolorization of only two dyes- DO 1 and DR 1 after 3 days. Using peptone as nitrogen source resulted in complete decolorization of DO 1 and DR 1 after 3 days while 88% and 22% decolorization were observed in case of dyes DR 167 and DR 30, respectively, after 8 days. In case of malt extract, complete decolorization was observed for dye DO 1 while 27%, 42% and 20% decolorization were obtained for DO 30, DB 79 and DR 1, respectively, between 6 to 8 days. Beef extract resulted in complete decolorization of DO 1 and DR 1 between 2 to 5 days while 42%, 23% and 90% decolorization were noticed in case of DR 167, DB 183 and DB 79, respectively, between 6 to 8 days (Fig. 2). In presence of yeast extract, isolate *Bacillus subtilis subtilis* showed complete decolorization of all the dyes between 18 h to 8 days except DB 186 which resulted in 56% decolorization after 8 days. Using peptone delivered complete decolorization of dyes, DO 1 and DR 167, between 7 to 8 days, while 12%, 84% and 96% decolorization were noticed in case of DO 30, DB 79 and DR 1, respectively, between 6 to 8 days. Malt extract resulted in complete decolorization of DR 167 after 2 days while 46%,



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20%, 39% and 32% decolorization were found in case of DO 30, DB 183, DB 79 and DR 1, respectively, between 6 to 8 days. Beef extract showed complete decolorization of DO 1, DR 167 and DO 30 after 2 days while 88% decolorization was obtained for DB 79 after 6 days. In case of ammonium nitrate, complete decolorization was observed for dyes, DO 1, DR 167 and DO 30 between 3 to 5 days. while 50% decolorization was obtained for DB 79 after 6 days. Sodium nitrate as nitrogen source resulted in complete decolorization of DO 1, DR 167 and DB 79 between 2 to 4 days while 28% and 80% decolorization was obtained in case of DY 198 and DB 79, respectively, after 8 days (Fig. 3).

Effect of carbon source

Different level of decolorization was observed utilizing different carbon sources. Isolate *Fictibacillus gelatini* showed complete decolorization of all the seven dyes in presence of maltose between 18h to 8 days. In presence of glucose, complete decolorization of dyes DO 1, DR 167 and DB 79 between 2 to 7 days was observed while 18% and 28% decolorization were obtained for dyes DO 30 and DR 1 respectively, after 8 days. In presence of fructose, 100% and 80 % decolorization were noticed in case of DO 1 and DY 198 respectively, between 4 to 5 days. Galactose resulted in complete decolorization of dyes- DO 1 and DR 1 respectively, between 2 to 3 days while 38% decolorization was obtained for DO 30 after 8 days. No decolorization of dyes was obtained in presence of mannitol. In presence of sucrose, complete decolorization were obtained for DO 1, DR 167 and DR 1 between 1 to 5 days. Complete decolorization of all dyes was observed in case of starch except DY 198 and DR 1 which showed no decolorization (Fig. 4). In presence of maltose as carbon source, isolate *Bacillus subtilis inaquosorum* resulted in complete decolorization of all the dyes between 18h to 8 days except DB 183 which showed no decolorization and 45% decolorization was observed in case of dye DR167 after 8 days. Using starch as carbon source also resulted in complete decolorization of all dyes between 2 to 8 days except DB 183 and DB 79 which showed no decolorization.

In case of Glucose, complete decolorization was observed only for DR 167 after 2 days and 25% and 15% decolorization were noticed for dyes DB 79 and DR 1 respectively, after 8 days. No decolorization was obtained in case of fructose and galactose. Mannitol resulted in complete decolorization of DO 1, DR 167 and DR 1 between 3 to 5 days while 50% decolorization was observed in case of DB 79 after 8 days. Sucrose resulted in complete decolorization of dyes DO 1, DO 30 and DB 79 between 3 to 4 days (Fig. 5). Utilizing maltose as carbon source, isolate *Bacillus subtilis subtilis* showed complete decolorization of all the dyes between 1 to 8 days except dye DB 183 which showed 56% decolorization after 8 days. In presence of glucose, complete decolorization was obtained for dyes DO 1, DR 167, DB 79 and DR 1 between 2 to 6 days while 63% and 80% decolorization were obtained for DY 198 and DO 30 respectively, between 2 to 8 days. No decolorization was obtained in case of fructose and galactose. Using mannitol resulted in complete decolorization of DO 1 and DR 1 between 4 to 5 days while 12%, 60% and 39% decolorization was obtained for DR 167, DB 183 and DB 79 respectively, after 8 days. In presence of sucrose, complete decolorization was noticed for DO 1 and DR 1 between 3 to 4 days while 17% decolorization was obtained for DB 183 after 8 days. In presence of starch, complete decolorization was obtained for DR 167 and DR 1 between 3 to 4 days while 92% and 79% decolorization was obtained for DO 1 and DB 79 between 4 to 6 days (Fig. 6).

Effect of bacterial consortia on decolorization of different dyes

Using a mixture of these three bacterial isolates (*Fictibacillus gelatini*, *Bacillus subtilis subsp. inaquosorum* and *Bacillus subtilis subtilis*) a consortium was prepared. Since almost all of the isolates gave useful results and the highest levels of decolorization were recorded above 60% to 100%, it was beneficial to create an effective consortium that could deliver significant results under all ideal conditions. Comparing the consortium to individual isolates, all the dyes were removed within 3 days under optimum conditions (Table 5).

Effect of bacterial consortia on different textile effluents

To determine the level of contamination for safeguarding the environment and natural resources, the classification of textile effluents is also necessary. Such an analysis report is crucial for textile industries to decide best prevention strategies for environmental pollution.

It was discovered that the pH of untreated effluents varies depending on the processes utilized in a certain company. Textile effluents L1, L2, B1 and B2 were treated with bacterial consortia. Typically, operations in textile companies



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were conducted at alkaline pH; however, distinct untreated raw textile effluents were found to have different characteristics; pH variations of the four effluents were 14, 12, 10 and 9.8; COD: 558, 800, 500 and 520 mg/l; TDS: 3442, 3860, 2793 and 2421mg/l and TSS: 1344, 1380, 1440 and 1540 mg/l. All the effluents have been treated at pH 7-8 and their physico-chemical characteristics improved with decrease in COD, TDS, TSS; their new values after treatment being COD: 130, 365, 210 and 265 mg/l; TDS: 2101, 2293, 1120 and 1181 mg/l and TSS: 140, 180, 100 and 202 mg/l respectively, their values got reduced to half or less than half after treatment (Table 6). Table 7 depicts the complete decolorization of effluents L1, B1 within 12 h and B2 within 4 days, whereas the effluent L2 was decolorized by 88% in 3 days.

DISCUSSION

Three isolates, identified as *Fictibacillus gelatini*, *Bacillus subtilis* subsp. *inaquosorum* and *Bacillus subtilis* subsp. *subtilis* were found to completely decolorize the dyes present in textile effluents. Enzymes-laccase, lignin peroxidase, azoreductase, and tyrosinase were found to be produced by these bacterial strains. The increased dye degradation of textile effluent by a bacterial coculture has been found to be very effective by other workers as well. Decolorization by oxidoreductase enzymes including laccase, NADH-DCIP reductase and azoreductase have been reported [27]. Abroad spectrum of textile dyes is mineralized by laccase enzyme [28]. The ideal temperature is a critical determinant of microbial growth, survival, and metabolic activities. The impact of temperature is a pivotal aspect in operations associated with microbial viability, including the bio-remediation of soil and water. The parametric optimization revealed that temperature of 37°C was optimum for dye biodegradation by bacterial isolates. At higher temperature, decolorization activity decreased due to degradation of reductase enzyme or loss of cell viability. A temperature between 30°C- 40°C was found to be optimum for decolorization of crystal violet by *Shewanella* sp. [29]. pH of the medium plays a critical role in dye decolorization process and pH 7.0 was found to be optimum for dye biodegradation in our studies. Enzyme metabolic activity is at its highest at this specific pH level, which makes it easier for the enzyme to attach to the active site of dye and boost the ability of dye to get decolorized. The rate of color removal is higher at the optimum pH level than at pH values that are too acidic or alkaline. The effectiveness of decolorization declines at lower pH values because dye cations cannot outcompete H⁺ ions. At high pH values, the strongest electrostatic interaction between the negatively charged surface of biomass and the positively charged dye cations is seen [27]. pH has a considerable impact on the efficacy of decolorization, with a typical pH range for color removal between 6.0 and 10.0 [30]. Optimal physiological performance of microbial cells and transport of various nutrient components across the cell membrane is crucially affected by pH of the medium.

Our results are in good agreement with [31], who reported that the decolorization of Methyl red by *Micrococcus* strain R3 was found in the pH range of 6.0–8.0. The optimum pH for dyes decolorization ranged between 6.5 and 7.5, as the maximum decolorization occurred at pH 7.0 [32]. The parametric optimization studies indicated that inoculum size 10% was optimum for dye degradation by bacterial isolates. A smaller inoculum volume decreases the biological reaction's overall rate, which lowers the rate of dye decolorization. However, inoculum volume over the optimized level causes early nutritional depletion and microorganism mortality, which lowers the rate of dye decolorization. The increase in *B. cereus* inoculum size from 2.5 to 10% increased the rate of TerasilBlack effluent decolorization; however, increase in inoculum up to 20% did not bring about any significant change in the color intensity [33]. Our parametric optimization results showed that complete dye decolorization by all the isolates under study was attained at dye concentrations- 100 ppm, 200 ppm and 500 ppm. The dye decolorization decreased by increasing its concentration beyond 500 ppm i.e., at 1000 ppm. When dyes are employed in high concentrations, dye decolorization is severely impeded, which may be due to the toxic impact of dyes on microorganisms. Bacterial isolate *Pseudomonas putida* MTCC 102 decolorizing the dyes by only up to 500mg/l [34]. Carbon and nitrogen sources also affect the decolorization process and the results showed that maltose and starch as carbon source and yeast extract as nitrogen source were optimum for complete decolorization of disperse dyes. Suitability of maltose can be due to the fact that *Bacillus* sp. lag phase was significantly shortened, resulting in an incubation time reduction from days to hours to achieve maximum dye elimination. Our results are in good agreement with [35], where *P. oestreatus* also showed



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significant shortening of lag phase by one day to cause maximum removal of dye in presence of maltose and starch and these co- substrates also showed stimulatory effect on dye decolorization. Yeast extract has stimulatory effect on the growth of diverse microorganisms which is useful for the decolorization of dyes upto the maximum level. Yeast extract as nitrogen source in synthetic media showed highest decolorization of blue HER by *Trichosporonbeigelii* [36]. When the consortium of our microbial strains was applied to the textile effluent, almost 50% reduction in COD, TDS and TSS of the effluent was achieved. Decolorization can be accomplished using a single, particular strain or co-cultivated microbes. Although bacterial decolorization was discovered to be quicker and more effective, disperse dyes are typically too complex for a single bacterial strain to entirely break down. The intermediate compounds, which must be further broken down, are frequently cancer-causing aromatic amines. Due to the synergistic metabolic activities of the microbial community, treatment systems made up of mixed microbial populations have a higher degree of biodegradation than those made up of pure cultures providing significant degradation of synthetic colors [37]. Decolorization of Disperse red 1 up to 80% was noticed within 72 h by potential bacterial consortium (*Microbacterium sp.*, *Leucobacteralbus*, *Klebsiella sp.* and *Staphylococcus arlettae*) at temperature 36°C and pH 7.0 [38]. These isolates decolorized the effluents containing disperse dyes along with reducing down the cost of entire treatment course. The current investigation can be highly noteworthy as these isolates decolorized these textile effluents almost completely making the effluent transparent from opaque. Apart from the cost reduction, there was much decrease in their TSS, COD and TDS and which were brought down by these microbes.

Other workers have similar findings of reduction of COD and BOD in the treated samples [39, 40]. Considering these facts, the current research can be potentially applied in bioremediating the industrial textile effluent. Studies were conducted for decolorization by these isolates and optimization of different nutritional and fermentation parameters (incubation periods, pH, temperature and dye concentrations) was also carried out. Decolorization studies for assessment of the ability of these strains on textile water effluents were also performed. It was seen that, higher decolorization was achieved at pH 7.0 and at a dye concentration up to 500 mg/l. Also, decolorization of a few dyes was also observed at a concentration of 1000mg/l in time lesser than anticipated. Similarly, four dye decolorizing isolates viz., *Bacillus sp.*, *Salmonella sp.*, *Klebsiella sp.* and *Pseudomonas species* were isolated from the textile effluent [41]. Out of which, *Bacillus sp.* was observed to be more efficient than other three strains in dye decolorization. Our studies indicated that using individual strains for dye decolorization of the textile effluent may not be as effective as using these microbes in the consortia. All these microbial strains when used singly led to complete dye decolorization in 18 hours up to 8 days. This time period was significantly reduced when they were used together leading to complete dye decolorization within 3 days. The nutritional and fermentation requirements of all these strains were similar which made the production and their application part both efficient as well as cost effective giving good results with supplementation of only minimum additives. This research can be efficiently used by the textile industries for decolorization and detoxification of their industrial effluents, thereby reducing the environmental pollution.

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Table 1: Enzyme Assay of Different Isolates

S.No.	Enzyme assay	Substrate	Enzyme Activity (IU/ml) <i>Fictibacillusgelatini</i>	Enzyme Activity (IU/ml) <i>Bacillus subtilis inaquosorum</i>	Enzyme Activity (IU/ml) <i>Bacillus subtilis subtilis</i>
1.	Laccase Assay	Guaicol& ABTSa	6.33±0.001 8.55±0.14	0.007±0.001 2.33±0.03	0.004 ± 0.001 0.001 ± 0.0002





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2.	Azoreductase Assay of Dyes b	Dye+NADHc	3.73±0.03	1.39±0.12	1.23 ± 0.02
3.	Tyrosinase Assay	Catechol	0.004±0.0001	0.003±0.001	0.007± 0.001
4.	Lignin Peroxidase	n-Propanol	0.010±0.0007	0.006±0.001	0.018 ± 0.0013

a- 2, 2'-azino-bis-(3-ethylthiazoline-6-sulfonate), b-dye, c- nicotinamide adenine dinucleotide.

Table 2: Optimized Parameters for Decolorization of Various Dyes by Isolate *Fictibacillusgelatini*

S.No	Parameters	Bacteria						
		<i>Fictibacillusgelatini</i>						
		DO 1	DY 198	DR 167	DO 30	DB 183	DB 79	DR 1
1	pH	7.0/ 18h	8.0, 9.0/4 d	7.0/18h	7.0/12d	7.0/2d	7.0/2d	7.0/2d
2	Temperature (°C)	37°C/18h	37°C/8d	37°C/18h	37°C/1d	37°C/2d	37°C/2d	30°C, 37°C/2d
3	Inoculum size (%)	10%/18h	7.5%, 10%/8d	10%/18h	10%/1d	10%/2d	7.5%, 10%/2d	10%/2d
4	Conc. of dye (ppm)	100, 500/18h	100/4d	100/12h	100/18h	100, 200, 500/2d	100, 200, 500/2d	500/2d
5	Nitrogen source	Yeast extract/18h	Yeast extract/8h	Yeast extract/18h	Yeast extract/1d	Yeast extract/2d	Yeast extract/2d	Yeast extract/2d
6	Carbon source	Maltose/18h	Maltose/8d	Maltose/18h	Maltose/1d	Maltose/2d	Maltose/2d	Maltose, starch/2d

Table 3: Optimized Parameters for Decolorization of Various Dyes by Isolate *Bacillus Subtilis Inaquosorum*

S.No.	Parameters	Bacteria						
		<i>Bacillus subtilis inaquosorum</i>						
		DO 1	DY 198	DR 167	DO 30	DB 183	DB 79	DR 1
1	pH	6.0/1d	7.0/6d	7.0/8d	7.0/1d	7.0	7.0/18h	7.0/2d
2	Temperature (°C)	37°C/2d	37°C/6d	40°C/2d	37°C/1d	-	37°C/18h	37°C/2d
3	Inoculum size (%)	7.5%, 10%/2d	10%/6d	7.5%/2d	7.5%/18h	-	10%/18h	10%/2d
4	Conc. of dye (ppm)	100/36h	100, 200/4d	100, 200/36h	100, 200, 500/1d	100, 200/2d	100/12h	100, 200, 500/2d
5	Nitrogen source	Peptone, Beef extract, Yeast extract/2d	Yeast extract/6d	Ammonium nitrate/4d	Yeast extract/1d	Beef extract/8d	Yeast extract/18h	Yeast extract/2d
6	Carbon source	Maltose, starch/2d	Maltose, starch/6d	Mannitol, starch/3d	Maltose/1d	-	Maltose/18h	Maltose/2d





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Table 4: Optimized Parameters for Decolorization of Various Dyes by Isolate *Bacillus Subtilis Subtilis*

S.No	Parameters	Bacteria						
		<i>Bacillus subtilis subtilis</i>						
		DO 1	DY 198	DR 167	DO 30	DB 183	DB 79	DR 1
1	pH	7.0/2d	7.0/8d	7.0/1d	7.0/2d	7.0/8d	7.0/18h	7.0/3d
2	Temperature (°C)	37°C/2d	40°C/4d	37°C/1d	37°C/2d	30°C/4d	37°C/18h	30°C, 37°C/3d
3	Inoculum size (%)	5%/2d	7.5%/7d	3%, 5%/1d	5%/2d	5%/8d	5%/18h	5%/3d
4	Conc. of dye (ppm)	100, 200/36h	100/2d	100, 200, 500/1d	200/36h	100, 200/1d	100/12h	100, 200/2d
5	Nitrogen source	Beef extract, Yeast extract/2d	Yeast extract/8d	Yeast extract/1d	Beef extract, Yeast extract/2d	Yeast extract/8d	Yeast extract/18h	Yeast extract/3d
6	Carbon source	Maltose/2d	Maltose/8d	Maltose/1d	Maltose/2d	Mannitol/8d	Maltose/18h	Glucose/3d

Table 5: Screening of Bacterial Consortium on Different Dyes

S. No.	Dyes	Decolorization by bacterial consortia
1	DO 1	C± 0.03/ 18h
2	DY 198	C±0.02/ 3d
3	DR 167	C± 0.32/ 1d
4	DO 30	C± 0.55/ 12h
5	DB 183	C± 0.17/ 1d
6	DB 79	C± 1.02/ 1d
7	DR 1	C± 1.5/ 2d

C- Complete decolorization (100%),
Time taken; h- hours, d- days

Table 6: Physico- Chemical Analysis of the Textile Effluents Before and After Treatment

Parameters	Observation before treatment of textile effluents				Observation after treatment of textile effluents			
	L1	L2	B1	B2	L1	L2	B1	B2
pH	14	12	10	9.8	7-8	7-8	7-8	7-8
Color	Purple	Brown	Dark green	Dark brown	Colorless	Light brown	Colorless	Colorless
COD	558	800	500	520	130	365	201	265
TDS	3442	3860	2793	2421	2101	2293	1120	1181
TSS	1344	1380	1440	1540	140	180	100	202

Table 7: Decolorization (%) of industrial effluents by consortium

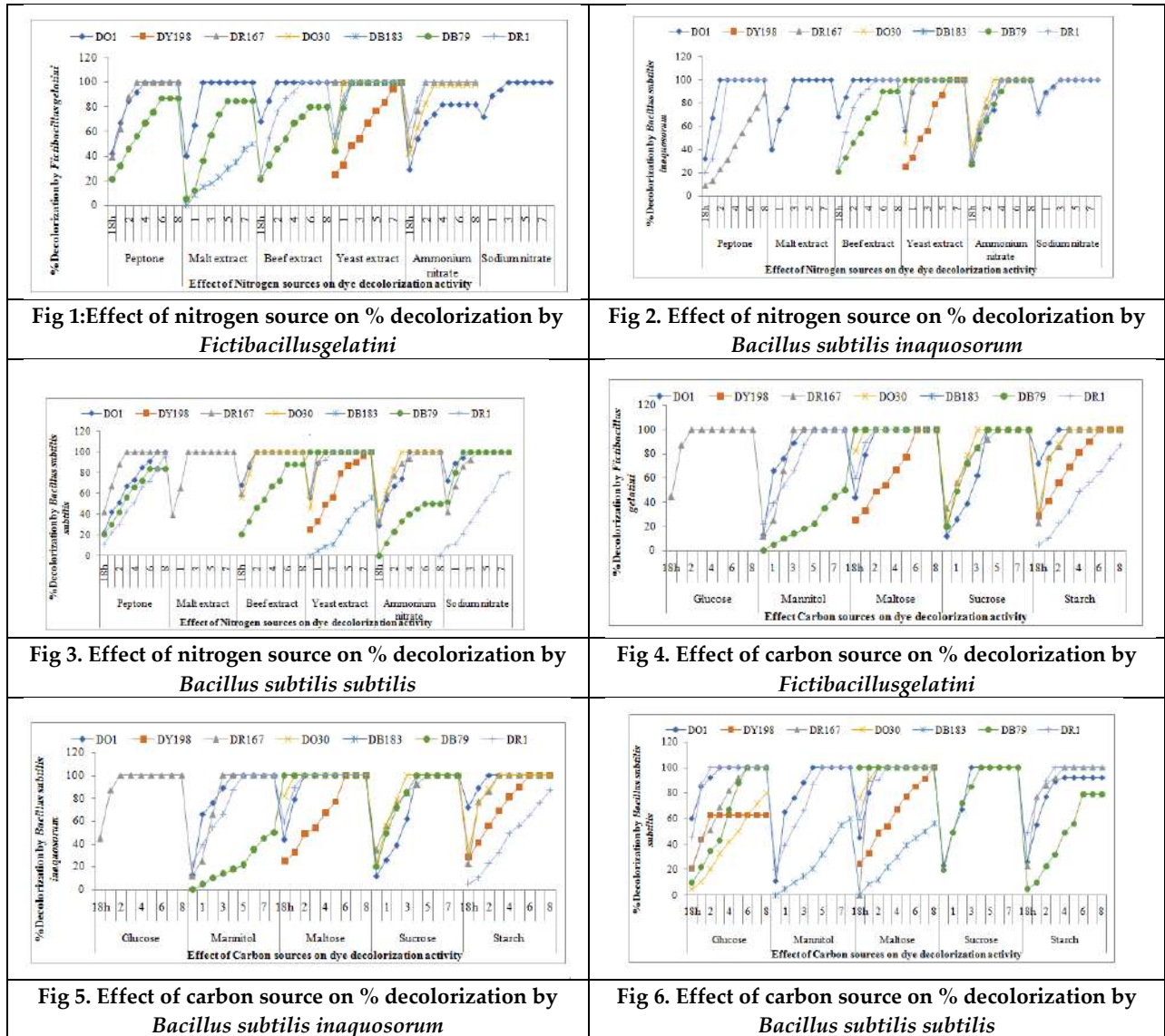
Textile effluents	Decolorization (%)
L-1	C± 0.04 in 12h
L-2	88± 0.18 in 3d
B-1	C± 0.03 in 12h
B-2	C± 0.01 in 4d

C-complete decolorization (100%)





Time taken; h- hours, d- days.





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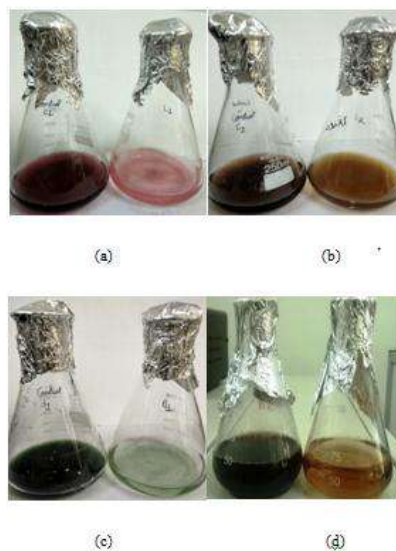


Fig 7: Comparison of untreated and treated textile effluent (a) Treated textile effluent L1, (b) Treated textile effluent L2, (c) Treated textile effluent B1, (d) Treated textile effluent B1





Strongly and Total Strongly Irregular Fuzzy Semigraphs

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ABSTRACT

This paper aims to pioneer and discuss the concept of strongly and strongly total irregular fuzzy semigraphs, conducting a comprehensive comparative examination of these two variants. We examine the unique features of strongly irregular fuzzy semigraphs and explore their relevance within the context of strongly totally irregular fuzzy semigraphs.

Keywords: Degrees, Fuzzy Semigraph, Irregular Fuzzy Semigraph, strongly irregular Fuzzy semigraphs, strongly total irregular fuzzy semigraphs.

INTRODUCTION

The introduction of fuzzy semigraphs was subsequently expanded by K. Radha and Renganathan.P [1]. Archana.s and Preethi Kuttipulackal further elevated the field through significant contributions to regular fuzzy semigraphs[2]. N R Santhi Maheswari and K.Amutha contributed in the study of Neighbourly Edge Irregular Graphs [3]. J. Krishnaveni Jeganathan and N R Santhi Maheswari produced significant findings to support strongly irregular fuzzy graphs, developing their core principles in this area. [4]. S.Nithishraj, A. Nagoor Gani and P.Muruganatham have explored the domain On Irregular Fuzzy Semigraphs adding valuable perspectives and findings[5]. This study aims to introduce the concepts of strongly irregular fuzzy semigraphs and strongly total irregular fuzzy semigraphs and





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provides a comparative analysis of the two. In addition, the paper analyses the characteristics of neighbourly and highly irregular fuzzy semigraphs, showing significant findings in the area.

METHODOLOGY

By using nodes, edges, adjacent degrees, and consecutive adjacent degrees, we can determine the characteristics of strongly irregular and total strongly irregular. Then, we may proceed to examine neighbourly and highly irregular fuzzy semigraphs.

STRONGLY AND TOTAL STRONGLY IRREGULAR FUZZY SEMIGRAPH

Definition 2.1: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. The degree of a node v is $d(v) = \sum \eta(E)$ where the summation now encompasses all edges E having v as a terminal node. A fuzzy semigraph \mathcal{G} is considered strongly irregular when each pair of connected nodes in \mathcal{G} have distinct degree. It is represented as $d_{\mathcal{G}}(v)$.

Definition 2.2: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. When every pair of connected nodes in a fuzzy semigraph \mathcal{G} has a distinct total degree, then \mathcal{G} is said to be strongly total irregular. It is represented as $td_{\mathcal{G}}(v)$.

Definition 2.3: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. If the edge degrees of adjacent nodes are distinct, we say that the fuzzy semigraph \mathcal{G} is strongly v -edge irregular. It is represented as $d_e(v)$.

Definition 2.4: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. If every pair of adjacent nodes has a distinct edge total degree, we say that the fuzzy semigraph \mathcal{G} is strongly v -edge total irregular. It is represented as $std_e(v)$.

Definition 2.5: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. When each pair of connected nodes in \mathcal{G} contains a distinct adjacent degree, we say that the fuzzy semigraph is strongly irregular in adjacent degree. It is represented as $d_{g_a}(v)$.

Definition 2.6: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. When each pair of connected nodes in \mathcal{G} contains a distinct total adjacent degree, then the fuzzy semigraph is strongly irregular in total adjacent degree. It is represented as $std_{g_a}(v)$.

Definition 2.7: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. When each pair of connected nodes in \mathcal{G} contains a distinct consecutive adjacent degree, we say that the fuzzy semigraph is strongly irregular in consecutive adjacent degree. It is represented as $d_{g_{ca}}(v)$.

Definition 2.8: Consider $\mathcal{G}: (\sigma, \mu, \eta)$ as a fuzzy semigraph in a semigraph $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$. When each pair of connected nodes in \mathcal{G} contains a distinct total consecutive adjacent degree, we say that the fuzzy semigraph is strongly irregular in total consecutive adjacent degree. It is represented as $std_{g_{ca}}(v)$.

EXAMPLE 2.9: Let $\mathcal{G}: (\sigma, \mu, \eta)$ represent a fuzzy semigraph in a given fig.1

All the nodes have distinct degrees, including the degree, edge degree, adjacent degree, consecutively adjacent degree, and its total degrees. Hence, the semigraph generated is both irregular and a totally irregular fuzzy semigraph as seen in the table above. It is easy to see that $d_{\mathcal{G}}(v) \leq d_e(v) \leq d_{g_{ca}}(v) \leq d_{g_a}(v)$ and $td_{\mathcal{G}}(v) \leq td_e(v) \leq td_{g_{ca}}(v) \leq td_{g_a}(v)$.





RESULTS AND DISCUSSION

Theorem 2.10 For a fuzzy semigraph $\mathcal{G}: (\sigma, \mu, \eta)$ is referred to $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$, where σ remains a constant function, the conditions i) and ii) are identical, indicating that \mathcal{G} is both a strongly and strongly total irregular fuzzy semigraph.

Proof: Assume σ remains a constant function.

(i.e.) $\sigma(p) = c$, for all $p \in v$.

Let us assume a strongly irregular fuzzy semigraph \mathcal{G} , in which each node has a distinct degree.

Consider a pair of nodes P_1 & P_2 , where P_1 and P_2 have distinct degrees T_1 and T_2 respectively.

(i.e.) $d_{\mathcal{G}}(P_1) = T_1$ and $d_{\mathcal{G}}(P_2) = T_2$ where $T_1 \neq T_2$

Suppose that all of the nodes in \mathcal{G} have the same total degree if \mathcal{G} is not a strongly total irregular fuzzy semigraph.

$$\Rightarrow d_{\mathcal{G}}(p_1) = td_{\mathcal{G}}(p_2)$$

$$\Rightarrow d_{\mathcal{G}}(p_1) + \sigma(p_1) = d_{\mathcal{G}}(p_2) + \sigma(p_2)$$

$$\Rightarrow T_1 + c = T_2 + c$$

$$\Rightarrow T_1 - T_2 = c - c = 0$$

$$\Rightarrow T_1 = T_2,$$

which is a $\Rightarrow \Leftrightarrow$ to $T_1 \neq T_2$.

Consequently, the implication (i) to (ii) is established by knowing that \mathcal{G} is a strongly total irregular fuzzy semigraph.

Assume that \mathcal{G} is a strongly total irregular fuzzy semigraph. Subsequently, the nodes total degree is all are distinct.

Let p_1 & p_2 be the pair of nodes have distinct total degrees T_1 and T_2 respectively.

Now, $d_{\mathcal{G}}(p_1) \neq td_{\mathcal{G}}(p_2)$

$$\Rightarrow d_{\mathcal{G}}(p_1) + \sigma(p_1) \neq d_{\mathcal{G}}(p_2) + \sigma(p_2)$$

$$\Rightarrow T_1 + c \neq T_2 + c$$

$$\Rightarrow T_1 - T_2 \neq c - c = 0$$

$$\Rightarrow T_1 \neq T_2$$

Therefore, \mathcal{G} is a strongly irregular fuzzy semigraph, which establishes the implication (ii) to (i).

As a result, we can deduce that (i) and (ii) are identical.

Theorem 2.11: For a fuzzy semigraph $\mathcal{G}: (\sigma, \mu, \eta)$ is referred to $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$, where σ remains a constant function, the conditions i) and ii) are identical, indicating that \mathcal{G} is both a v -edge degree in strongly irregular fuzzy semigraph and a v -edge degree in strongly total irregular fuzzy semigraph.

Proof: Let σ remains a constant function.

(i.e.) $\sigma(p) = c$, for all $p \in v$.

Suppose we have a v -edge degree in strongly irregular fuzzy semigraph \mathcal{G} where the edge degree of its nodes all are distinct.

Consider a pair of nodes P_1 & P_2 , where P_1 and P_2 have distinct degrees T_1 and T_2 respectively.

(i.e.) $d_e(P_1) = T_1$ and $d_e(P_2) = T_2$ where $T_1 \neq T_2$

The proof follows a similar structure as the proof of theorem 2.10.

REMARK 2.12: A v -edge strongly irregular fuzzy semigraph and the total degree is highly irregular. Fig.2.

Now, $d_e(p)=0.6$, $d_e(Q)=0.5$, $d_e(R)=0.7$, $d_e(S)=0.8$, $d_e(T)=0.4$ and $td_e(p)=1.3$, $td_e(Q)=0.9$, $td_e(R)=1.3$, $td_e(S)=1.3$, $td_e(T)=1$. In this case, the nodes of the semigraph have distinct edge degrees and are considered strongly irregular, and the total edge degree of the nodes is also distinct. Therefore, the fuzzy semigraph is highly irregular in total edge degrees.





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Theorem 2.13: For a fuzzy semigraph $\mathcal{G}: (\sigma, \mu, \eta)$ is referred to $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$, where σ represents a constant value, the conditions i) and ii) are identical, indicating that \mathcal{G} is both an adjacent degree in strongly irregular fuzzy semigraph and an adjacent degree in strongly total irregular fuzzy semigraph.

Proof : Let σ remains a constant function.

(i.e.) $\sigma(p) = c$, for all $p \in v$.

Suppose we have an adjacent degree irregular fuzzy semigraph \mathcal{G} where the adjacent degree of its nodes all are distinct.

Consider a pair of nodes P1 & P2, where P1 and P2 have distinct degrees T_1 and T_2 respectively.

(i.e.) $d_{\mathcal{G}_a}(P_1) = T_1$ and $d_{\mathcal{G}_a}(P_2) = T_2$ where $T_1 \neq T_2$

The proof follows a similar structure as the proof of theorem 2.10.

REMARK 2.14: An adjacent degree is neighbourly irregular fuzzy semigraph and its total degree is strongly irregular. Fig.3.

Now, $d_{\mathcal{G}_a}(p)=0.7$, $d_{\mathcal{G}_a}(Q)=0.6$, $d_{\mathcal{G}_a}(R)=0.9$, $d_{\mathcal{G}_a}(S)=0.8$, $d_{\mathcal{G}_a}(T)=0.6$ and $td_{\mathcal{G}_a}(p)=0.9$, $td_{\mathcal{G}_a}(Q)=1.1$, $td_{\mathcal{G}_a}(R)=1.2$, $td_{\mathcal{G}_a}(S)=1$, $td_{\mathcal{G}_a}(T)=1.3$. In this case, the nodes of the semigraph have distinct adjacent degrees and are considered neighborly irregular, and the total adjacent degree of the nodes is also distinct. Therefore, the fuzzy semigraph is strongly irregular in adjacent total degrees.

Theorem 2.15: For a fuzzy semigraph $\mathcal{G}: (\sigma, \mu, \eta)$ is referred to $G: (\mathcal{V}, \mathcal{E}, \mathcal{X})$, where σ remains a constant function, the conditions i) and ii) are identical, indicating that \mathcal{G} is both a consecutive adjacent degree in strongly irregular fuzzy semigraph and a consecutive adjacent degree in strongly total irregular fuzzy semigraph.

Proof: Let σ remains a constant function.

(i.e.) $\sigma(p) = c$, for all $p \in v$.

Suppose we have a consecutive adjacent degree irregular fuzzy semigraph \mathcal{G} where the consecutive adjacent degree of its nodes all are distinct.

Consider a pair of nodes P1 & P2, where P1 and P2 have distinct degrees T_1 and T_2 respectively.

(i.e.) $d_{\mathcal{G}_{ca}}(P_1) = T_1$ and $d_{\mathcal{G}_{ca}}(P_2) = T_2$ where $T_1 \neq T_2$

The proof follows a similar structure as the proof of theorem 2.10.

REMARK 2.16: A consecutive adjacent degree is strongly irregular fuzzy semigraph and its total degree is neighbourly irregular. Fig.4. Now, $d_{\mathcal{G}_{ca}}(p)=0.5$, $d_{\mathcal{G}_{ca}}(Q)=0.7$, $d_{\mathcal{G}_{ca}}(R)=1$, $d_{\mathcal{G}_{ca}}(S)=1.1$, $d_{\mathcal{G}_{ca}}(T)=0.9$, $d_{\mathcal{G}_{ca}}(U)=0.6$ and $td_{\mathcal{G}_{ca}}(p)=1.2$, $td_{\mathcal{G}_{ca}}(Q)=1.1$, $td_{\mathcal{G}_{ca}}(R)=1.9$, $td_{\mathcal{G}_{ca}}(S)=1.2$, $td_{\mathcal{G}_{ca}}(T)=1.6$, $td_{\mathcal{G}_{ca}}(U)=1$. In this case, the nodes of the semigraph have distinct consecutive adjacent degrees and are considered strongly irregular, and the consecutive adjacent total degree of the nodes is also distinct. Therefore, the fuzzy semigraph is neighborly irregular in consecutive adjacent total degrees.

Theorem 2.17: For a fuzzy semigraph $\mathcal{G}: (\sigma, \mu, \eta)$ is strongly irregular fuzzy semigraph then it is both highly irregular and neighbourly irregular fuzzy semigraph.

Proof: Let \mathcal{G} be a strongly irregular fuzzy semigraph. It follows that every pair of nodes in \mathcal{G} has distinct degrees. Clearly, it is obvious that every consecutive pair of nodes in \mathcal{G} has distinct degrees, and each node in \mathcal{G} is connected to nodes with distinct degrees. Consequently, \mathcal{G} can be defined as a neighbourly irregular and highly irregular fuzzy semigraph.

Theorem 2.18: For a fuzzy semigraph $\mathcal{G}: (\sigma, \mu, \eta)$ is highly irregular and neighbourly irregular fuzzy semigraph is not required to be a strongly irregular fuzzy semigraph.





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Proof: The nodes P&Q of G , which are neither adjacent nor incident on the same node can have the same degree, contradicting the definition of a strongly irregular fuzzy semigraph.

CONCLUSION

This study, conducted a comprehensive analysis of strongly irregular and totally strongly irregular fuzzy semigraphs, delving into their edge, adjacency, and consecutive adjacency degrees. A thorough comparative investigation between strongly irregular and strongly total irregular fuzzy semigraphs was carried out, along with a detailed examination of neighbourly and highly irregular fuzzy semigraphs.

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Table:1

END NODES	P	R	T
$d_G(v)$	0.6	0.9	0.4
$d_e(v)$	0.6	0.9	0.4
$d_{G_a}(v)$	1.2	1.5	0.4
$d_{G_{ca}}(v)$	0.6	1	0.4
MIDDLE NODES	Q		
$d_G(v)$	0		
$d_e(v)$	0.5		
$d_{G_a}(v)$	1.1		
$d_{G_{ca}}(v)$	1.1		
MID- END NODES	S		
$d_G(v)$	0.7		
$d_e(v)$	0.7		
$d_{G_a}(v)$	0.7		





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$d_{G_{Ca}}(v)$	0.7		
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Table:2

END NODES	P	R	T
$td_G(v)$	1.4	1.6	1.3
$td_e(v)$	1.4	1.6	1.3
$td_{G_a}(v)$	2	2.2	1.3
$td_{G_{Ca}}(v)$	1.4	1.7	1.3
MIDDLE NODES	Q		
$td_G(v)$	0		
$td_e(v)$	1		
$td_{G_a}(v)$	1.6		
$td_{G_{Ca}}(v)$	1.6		
MID- END NODES	S		
$td_G(v)$	1.2		
$td_e(v)$	1.2		
$td_{G_a}(v)$	1.2		
$td_{G_{Ca}}(v)$	1.2		

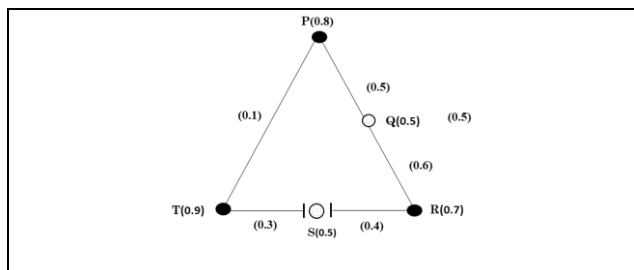


Fig-1

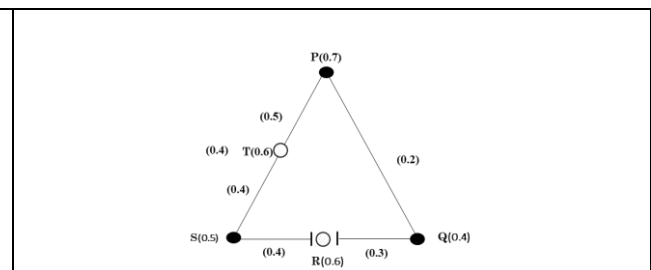


Fig-2

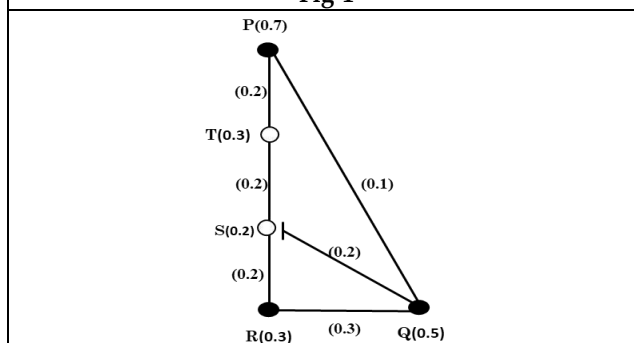


Fig-3

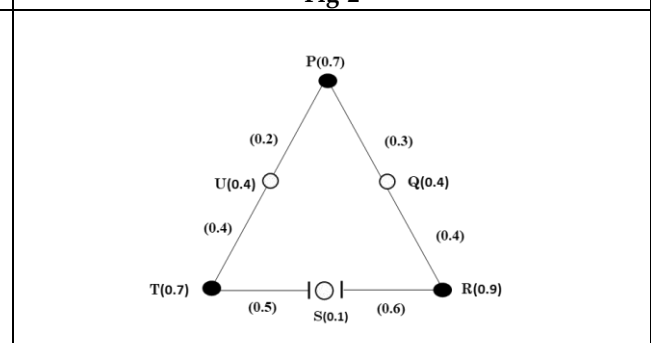


Fig-4





Bandicoot - One Stop Robotic Solution to Manual Scavenging in India

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ABSTRACT

The study develops substantial insights about the current situation regarding the still-pervasive, life-threatening practice of manual scavenging in India. It tries to understand the significance of Bandicoot, a robotic solution for the eradication of years-old manual scavenging practices and bringing commendable transformation to the lives of sanitation workers. Overall, it focuses on development of analytical skills towards designing robotic solutions for addressing pressing social issues by seamlessly combining robotics and artificial intelligence. Despite the enactment of The Prohibition of Employment as Manual Scavengers and Their Rehabilitation Act in 2013, employment as a manual scavenger is still allowed in India. With the vision of eradicating manual scavenging from the world, Bandicoot 2.0 was introduced in 2017 for cleaning any type of sewer manhole. With the interactive and user-friendly interface of Bandicoot, the poor manual scavenger's position has been elevated to that of a robot operator, preserving their dignity for leading a respectful life in society. The study is primarily based on secondary data, which was gathered through consulting business newspaper articles about the practice of manual scavenging in India and media stories explaining Genrobotics' development of Bandicoot. Additional data is gathered from the company's website, <https://www.genrobotics.org/>. For extracting relevant current information in the context of Bandicoot and manual scavenging, many other websites are referred to, like keralainsider.com, outlookindia.com, dailypioneer.com, and republicworld.com. Information about manual scavenging has been taken from reports by the Tata Trust Policy and the Public Information Bureau.

Keywords: Manual Scavenging, Robotic, Manhole, Cleaning, Sanitation



**Arnaz Kaizad Wadia****INTRODUCTION TO HEARTBREAKING TRUTH OF SANITATION WORKERS IN INDIA**

It is often said that anyone who is dissatisfied with their employment should only contrast it with the work of a manual scavenger in order to experience a miracle. One will undoubtedly feel fortunate to have a job that doesn't demand draining down dignity at the risk of life in a pitiful condition in a manhole. Fatalities with manhole cleaners are very common. Still, the contractors are least bothered to ensure safety precautions like a mask, safety belts, poisonous gas detectors, and checking oxygen levels for their sanitation workers just to cut down on the cost of cleaning. This dire situation raised the question of how to improve the miserable state of manhole cleaners. It's really difficult to come up with an effective remedy in the form of real safety protection for manual scavengers other than their very own prayers for all turning up well while entering the manhole. As manhole cleaners cover their noses and mouths with a small piece of cloth and work barehanded, the question is raised about how someone's life can be so cheap. Simultaneously, the need to get an answer to the question of who is responsible for this situation was strongly felt. Moreover, the major concern was the eradication of the centuries-old practice of manual scavenging, but how? With the birth of Bandicoot by Genrobotics, the much-needed hope of an effective solution for abandoning manual scavenging was enlightened. However, there was a big challenge in how to design the robotic scavenger capable of replacing manholes with robot holes. As an alternative, the dilemma of how successful a robotic scavenger would be compared to a manual scavenger was brought up. Additionally, Bandicoot's success led to the dilemma of how to secure alternate sources of livelihood for all those people who have relied solely on manual scavenging as their only source of income for years. Because of this, a dilemma about whether Bandicoot would be able to bring about the much-needed transformation in sanitation workers' lives and enable them to carry on with their centuries-old practice of cleaning manholes without putting their safety or dignity in danger persisted along with its invention.

While these hazy clouds of confusion were wandering around, Considering the report of the Census of India (2011), it is observed that there are 7,94,390 dry latrines, with almost 73% in rural areas and the remaining in urban areas where men need to clean excreta. Although the employment of manual scavengers was outlawed in India many years ago, they are still employed to clean dry latrines, blocked gutters, and sewers all over the country. This emphasized the urgent need for an amicable solution to the issue that would allow the decades-old manual scavenging practice to continue while also taking all necessary precautions to ensure the cleaners' safety and security. In light of the foregoing debate, a number of questions were raised, such as what constitutes a workable solution to the issue of manual scavenging. How could a solution be derived? Can Bandicoot be a proven solution sufficient enough to fully address the pressing issue of manual scavenging? Moreover, it is worth noting that there has been a sudden spurt in the number of fatalities resulting in the deaths of sanitation workers. In one of the articles published in *The Hindu* on July 20, 2022, it is claimed that in the last five years, almost 347 people have died in India while cleaning sewers and septic tanks. Approximately 40% of these fatalities took place in Uttar Pradesh, Tamil Nadu, and Delhi. However, as per the Press Information Bureau scavengers in the country report posted on March 30, 2022, in total, state-wise, 325 sewer deaths were reported. Its details are highlighted in Table 1 below: Despite the enactment of The Prohibition of Employment as Manual Scavengers and Their Rehabilitation Act in 2013, employment as a manual scavenger is still continued. Sewers enter manholes in the daytime only, and it is considered government or corporation work, and not claimed as illegal. That's the tragedy. Therefore, a National Action Plan for Rs. 1.25 lakh crore was created with government intervention on March 6, 2020, to phase out manual scavenging with high-tech machines in 500 cities and gram panchayats (*Daily Pioneer*, 2020). However, as per the survey conducted in 2013 and 2018 in the context of Ministry of Social Justice and Empowerment Directive, manual scavengers were identified state-wise as follows in Table 2: These facts and figures presented a clear picture of the pathetic state of manual scavenging today. Also these discussions presented the biggest dilemma, namely whether Bandicoot will be a blessing for sanitation workers, protecting them as they clean septic tanks or gutters, or a curse, stealing their means of subsistence through their decades-old practice of manual scavenging.



**Arnaz Kaizad Wadia****Birth of Genrobotics**

Genrobotics, the leading robotics company headquartered in Trivandrum, Kerala, India, was born out of the novel idea of providing service to the Indian army by developing a tailor-made product for soldiers to lift heavy military weapons at remote locations. It was in 2015 when Vimal Govind MK, Arun George, and Nikhil NP, all at 25 years of age, and Rashid Bin Abdulla Khan, at 24 years of age, came together to incubate this idea into reality in the form of Genrobotics, with a common interest in powered exoskeleton technology since their college days at MES College of Engineering in Kuttippuram, Kerala. Together, they developed the first-generation GI-powered exoskeleton, a wearable mobile machine that helps soldiers carry heavy military equipment in off-the-grid settings. This development was entitled Iron Man Suit. The G2 medical exoskeleton, which the team developed, has proven to be a blessing for physically challenged people, like amputees. It ensured their standing up and forging ahead in every step of their lives. As a result of this advancement, they won the best concept prize at the 2016 International Conference on Mechatronics and Manufacturing in Singapore (Forbes India, 2022). The group presented these developments while working with the Kerala Startup Mission (KSUM). Once their engineering studies were completed, they could not immediately continue with their experiments due to a lack of funds. This compelled them to take up IT-related jobs. However, their desire for innovation led them to attend any event where people were discussing the most recent advancements in robotics. Luckily, in 2016, they happened to meet IT Secretary Mr. Sivasankar at an event organized by KSUM, wherein they were enlightened about the burning issue of manual scavenging and the necessity to develop a workable solution. They quickly understood that working in this direction required full-time employment and was a very time-consuming chore. Therefore, they abandoned their well-paying careers despite the wishes of their families and friends because of the commitment needed to the new endeavor.

Left with just their savings, they once again brought Genrobotics to life. Additionally, as co-founder Mr. Rashid mentioned, the idea to start with Genrobotics came to them upon reading a newspaper article describing the asphyxiation deaths of two sewage cleaners and an auto driver who attempted to rescue cleaners in a manhole at Kozhikode. The company finally got registered in 2017 thanks to a grant of 10 lacs from KSUM. This led to the establishment of Genrobotics on June 21, 2017. In addition, five more students joined a core group to transform manholes into robot holes. Because of the team's dedication to their objective, they worked nonstop for days and nights without being disturbed by anything else. Since they were all sharing a single room, they could work together. It was important to figure out exactly what was needed. What was the size of the manhole, what were the problems with sewers, which were the major difficulties faced on entering the manhole, etc.? In the search for answers to these questions, they met and discussed them personally with engineers and sewer workers. These discussions turned out to be very fruitful for them, leading to the development of Bandicoot with the unique feature of adjustable expansion and contraction of robot legs to fit different sizes of manholes. Genrobotics won the first Startup Innovator Award by the Kerala Water Authority (KWA) and an innovation grant of 14 lacs based on the development of Bandicoot. This led to the production of its beta version in only a month. Then after, there was no looking back, with the Kerala Water Authority becoming the first public organization to deploy Bandicoot in Thiruvananthapuram. This way, the success story continued with receiving orders outside the state from other states like Tamil Nadu, Karnataka, Andhra Pradesh, and even international orders from Sharjah. Thus, the team tried hard to develop technology-driven solutions for the nation's problems, but due to financial constraints and the high price of imported parts, they halted their efforts. However, the Kerala Startup Mission (KSUM), the state government's nodal agency for the development of startups and entrepreneurship support to replace the job of manual scavenging with technology, led to the birth of Bandicoot, a robotic solution from Genrobotics for replacing men with a machine for cleaning manholes. This turned out to be the biggest blessing for sanitation workers, saving them from manhole-related deaths.

Genrobotics - Product Portfolio

Three robotic solutions, Bandicoot, Wilboar, and G-Beetle, are offered under the product portfolio of Genrobotics. The names of the Bandicoot and Wilboar robots are derived from the names of animals fond of doing similar work, such as searching underground, just like the robots do while cleaning manholes and other confined spaces. Manholes of any kind are cleaned with the robotic solution of Bandicoot. The robot is composed of two units: a stand unit and a robotic drone unit. A drone unit enters a manhole. Its dive depth is adjusted according to the situation. Any corrosive





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sewage situation is handled with a nanocoating in addition to a powder coating. A number of tasks are performed by the drone unit's extending robotic arm, such as grabbing, shovelling, and unclogging manholes. For high-definition displays, the drone units are outfitted with IP68 waterproof cameras. Moreover, the drone unit is tracked continuously with the sensor-based feedback system. This has raised the standard of cleaning without human involvement. Confined spaces like petroleum tanks, sewers, and water treatment plants are cleaned with the technically advanced solution of Wilboar 2.0. The hard sludge in confined spaces is unclogged by the Wilboar high-pressure water jetting system. The waste gets accumulated in the waste collection chamber with the in-built sucking module. Also, tanks are examined from outside with the help of Wilboar ATEX-certified high-resolution machine vision technology for the identification of any kind of sludge. G-Beetle is used for cleaning the skyscraper facade. It has brought a much-awaited revolution to the safety and security of skyscraper facade cleaners. G-Beetle made cleaning and beautification possible without being concerned about the frightening heights of skyscrapers. Its productivity standards are augmented by the robotic drone system and artificial intelligence. During the cleaning process, the required facade contact is maintained by the dynamic balancing of propellers and thrusters. Thus, G-Beetle offered a solution for performing the world's most dangerous jobs at ease without threatening the lives of cleaners working at great heights.

Working of the Robotic Scavenger-Bandicoot

For easier portability, Bandicoot has four robotic legs. Solid waste is removed by its 360-degree rotating robotic arms from every nook and cranny of the manhole. Water jets are fitted to them in order to eliminate sewage obstructions. Through the night vision cameras that are attached to them, a clear image of the interior of the manhole is obtained. The robot may be operated by itself. It comes with features including dirt-proofing, waterproofing, and corrosion protection. Most crucially, it possesses the competency to complete the task of three manual scavengers' three-to-four-hour work in only 45 minutes. The robot can effortlessly raise the bulky manhole covers, which formerly required at least two to three workers. The sensors that are attached to them can also be used to detect poisonous gases. Bandicoot robots use artificial intelligence to mimic any human movement. It is capable of carrying out a variety of activities, including excavating, holding, picking up, and positioning the water-jet for specific cleaning. Any human hand movements are replicated by robotic arms. Considering these numerous benefits of Bandicoot, 17 states have started to avail of its services, including Madhya Pradesh, Maharashtra, Haryana, Gujarat, Uttar Pradesh, Punjab, Andhra Pradesh, Kerala, Tamil Nadu, Assam, Rajasthan, etc. And this way, it has resulted in the successful eradication of years-old barbaric practices of caste-wise discrimination by forcing Dalits to perform all degraded jobs like manual scavenging. Bandicoot 2.0 is proven to be the best technology for enabling zero human intervention in the cleaning process of hazardous gutters, manholes, and septic tanks. Moreover, Bandicoot has successfully contributed to the "Swachh Bharat Abhiyan and Make in India" initiatives of the Government of India. It is evident of our nation's prospering progression. Being designed and manufactured completely in India, it has set an exemplary role model for promoting the Aatma Nirbhar Bharat Abhiyan. Bandicoot has worked wonders in people's lives. As per the article dated December 6, 2021 in The Hindu Business Line Sachin Yadav, a 42-year-old sanitation worker working for Brihanmumbai Municipal Corporation (BMC) for the last 14 years, finds a radical change in his life. As of now, there is a robot working as a ginny in his place, performing all his life-threatening jobs. Bandicoot proved to be a blessing that completely changed his life. Now, he is not supposed to enter the manhole, and his work is done much quicker. This assured his family of his safety. As the robot cleans and removes clotting from any type of manhole and septic tank. From the very beginning of the cleaning process, which starts with the lifting of the gutter covers, to finally collecting the solid waste in a bucket, the robot is well equipped to perform the complete cleaning process without human intervention. Infrared cameras mounted on Bandicoot help project the interiors of the manhole on the monitor screen beforehand only. This assures easy cleaning with a clear picture of a blocked manhole.

Mitigating Covid-19 and Occupational Hazards Risk with Bandicoot

The best part about Bandicoot was realized at the time of COVID-19. The robot worked out as a real miracle at that time, providing Indian sanitation workers with the advantage of operating a manhole from a distance without compromising on any kind of safety measure. During the pandemic, sanitation workers were the front-line workers,



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and they were exposed to hazardous waste on a daily basis. Moreover, due to the COVID-19 situation, a tremendous surge in waste in the form of used masks, gloves, and other bio-hazardous materials was observed. This was an alarming situation at the places where manual scavenging was practiced, threatening the lives of sanitation workers. In this hard situation, Bandicoot provided a much-needed protection shield. Getting involved with manual scavenging can be as risky as ending a life. Because breathing in harmful chemicals within sewers can be fatal. According to data from Safai Karmachari Andolan (SKA), manual scavengers—who are primarily women—are paid between 180 and 200 rupees per month per household and have an average life expectancy of 40 to 45 years, along with the threat of hepatitis, cholera, meningitis, typhoid, and cardio-vascular problems (The Hindu Businessline 2021, December 06). The article also mentioned records from the National Commission for Safai Karamcharis, which stated 376 deaths between 2015 and 2019 while clearing septic tanks and sewers, as well as the presence of 62,904 manual scavengers between December 2013 and January 2020. This data illustrates the challenging environment in which manual scavenging is practiced in India.

Manual Scavengers Social Obligation in India

Manual scavengers hesitate to reveal their identities. They work most of the time without any kind of protective measure except a rope tied around their waist. It is observed that in India people take up the work of manual scavenging because there are no other job options. And once they take up this task of making the world a better place to live, they end up making their lives hell. Once a manual scavenger tag is applied, no other job is entrusted to him. Even in Indian societies, manual scavenging is always looked down upon as a dignity-less job. To stand on par with society's social obligations, manual scavenger identity is hidden just to get the much-needed acceptance and equally fair treatment that are the rights of every citizen in India, the world's largest democracy. Tata Trusts and the Municipal Corporation of Greater Mumbai jointly initiated Mission Garima in March 2014 to restore the dignity of sewers. The mission emphasized greater usage of technology to minimize manual handling of waste. However, effective results showcasing upliftment in the dignity of manual scavengers were not observed.

Indian Government Measures and Policies for Abolishing Manual Scavenging

No one may be required to perform manual scavenging in accordance with the Civil Rights Act of 1955. Aiming to end the practice of manual scavenging, the Employment of Manual Scavengers and Construction of Dry Latrines (Prohibition) Act of 1993 and the Prohibition of Employment as Manual Scavengers and Their Rehabilitation Act of 2013 were both passed. In addition, the Supreme Court declared on March 27, 2014, that the government must step in to end the practice of manual scavenging and to rehabilitate those who got engaged with it. This guarantees the constitutional obligation to help sewers find better alternative work in order to regain their diminished dignity. The Building and Maintenance of Insanitary Latrines Act of 2013 also forbids the development of such facilities (Outlook India, 2022). It assures the demolition of insanitary toilets or their conversion into sanitary toilets. Therefore, despite all of the legal restrictions that are currently in place to stop manual scavenging, a large number of people from lower social classes have started engaging in it. This reflects administrative inefficiency in the successful implementation of an established law prohibiting one of the most disrespectful manual scavenging practices. Moreover, the worst part of manual scavenging is believed to be untouchability and disrespect for those engaged in this work. As in India, manual scavenging has historically been institutionalized based on caste differentials. Since there are no better employment options, the majority of the people who got engaged in manual scavenging are members of the downtrodden and disadvantaged class.

Bandicoot collaboration with IOCL & other Institutions

In June 2022, IOCL teamed up with Genrobotics to develop a robotic cleaning solution for refineries in light of the widespread success of Bandicoot, the first robotic scavenger in history. At the moment, Bandicoot is used in refineries to clean storm-water and oily sewers. Bandicoot is used by numerous different public and private sector organizations in order to minimize human intervention while cleaning manholes. Indore and Surat Municipal Corporations (SMC), which received the accolade for being the cleanest cities, also make use of Bandicoot services. Additionally, an announcement regarding expanding the use of Bandicoot 2.0R robots for cleaning refineries was made on the 63rd Foundation Day of IOCL. The fire-resistant feature of Bandicoot 2.0R has made it the ideal choice



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for cleaning the OWS and SWS of refineries. Both the Municipal Committee of Leh and the Municipal Corporation of Pune use bandicoot services. Now that Leh has a robotic scavenger, even bad weather doesn't hinder the manhole cleaning process there. With Bandicoot's development, the Municipal Committee of Leh is better able to support the Ministry of Housing and Urban Affairs' Safai Mitra Suraksha Challenge and Mission Zero Manual Scavenging. Bandicoot is being used by the municipal corporations of Ullhasnagar and Dhule to repair the manholes in the cities. The 16th state to adopt Bandicoot is Rajasthan. Kanpur Smart City Limited has shifted to robotic cleaning with Bandicoot as part of the Smart City Programme.

Bandicoot Turnaround Story

The Ministry of Housing and Urban Affairs (MOHUA) recognized Bandicoot: The Robotic Scavenger as the best innovation for eradicating the practice of manual scavenging. It won the Swachhta Start-Up Challenge in September 2022. Due to its highly advanced technology, this robotic scavenger offered not only societal and environmental benefits but also financial ones as well. As it cleaned 10 manholes in contrast to a manual scavenger's capacity of cleaning just one or two manholes every day. As a result, there are significant labour savings compared to what would have been necessary for manual scavenging. In places where other technology, like grabbing machines, fails to extract solid waste, the bandicoot offers much more advanced technology for cleaning by reaching every corner of the confined manhole. Its services are utilized on a daily basis by 17 states in addition to numerous other urban local bodies, smart cities, and refineries. Thus, it is evident that Mission Robohole, geared by Genrobotics is advancing every day. According to an article in the Times of India from June 8, 2022, Mr. Govind claims that more than 1 lakh robots will be needed to put an end to manual scavenging in India. The main cause driving the demand for Bandicoot deployment is rapid urbanization. In this context, the comment made by Mr. Rashid in the CNBC TV18 Upadhyay, A. (2022, July 19) report is worth noting that "Version 2.0 of Bandicoot is currently available for Rs 39.5 lakh (including the goods and services tax) makes clear that its demand is flourishing. From a small office in 2017, we now have a 12,000 square foot production area in Thiruvananthapuram and one in Palakkad". Additionally, Genrobotics and Google have partnered to offer a better user interface. Furthermore, Bandicoot provides built-in training assistance. This assures efficient learning for sanitation workers in less time. All these developments cleared the dilemma about success of Bandicoot for bring much-needed transformation in lives of sanitation workers.

Future Prospect of the Robotic Scavenger

The illegal practice of manual scavenging can be stopped by Bandicoot. It has been recognized by Ministry of Housing and Urban Affairs and Smart City Mission India. The chairman of the Mahindra Group, Anand Mahindra, also made an investment in Genrobotics as stated in one of S. Chowdhary's articles from Financial Express (2020, October 19). Anand Mahindra also tweeted that there are many worries about how AI and robots will affect society in the future in light of this fantastic invention and its capabilities. Nevertheless, he would still continue to offer prayers at the temple of technology and robotics if robots could free people from this most abhorrent job in the universe. Considering this innovative advancement, Bandicoot could be considered one of the most innovative robotic solutions, reflecting the progression of progressive Swach Bharat. Additionally, the Genrobotic Innovations founders have been chosen for a fellowship by the influential Adani Group. According to the article in The Hindu (2022, December 26), the fellowship will assist Genrobotics in growing its business into new industries and creating solutions for a range of social issues. Also, it stated that with the company's foray into overseas markets like the UK, Malaysia, UAE, and South Korea, the organization's brighter prospects are very apparent.

The capability of Bandicoot to be technically advanced yet user-friendly has highlighted it in the eyes of global-level marquee investors. Stepping one step ahead, global-level expansion of the organization is possible with its unique and novel robot manufacturing capacity. It is also worth noting that the rehabilitation of sewer workers who lost their jobs due to automation is carried out throughout the year at Genrobotics. They are rehabilitated by training them to operate Bandicoot. Additionally, Bandicoot has been designed to provide a simple user interface that ensures seamless navigation of controls. This measure taken by Genrobotics acts as a protection shield for the daily earnings of sewer workers and doesn't let technology snatch away means of livelihood from the hands of the workers. The most rewarding moment, though, for Mr. Arun, one of the Genrobotics co-founders, is witnessing a sewage worker



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transformed into a machine operator. Diligently handling the machine without being tortured by getting into the sewage lines full of toxic and hazardous gases. Genrobotics' success disproves the notion that hardware start-up companies frequently fail and have lengthy gestation periods. It exemplifies how Bandicoot's solution to the critical social issue of manual scavenging provided a lifeline for low-paid sanitation workers and ultimately turned out to be an incredible blessing for humanity. Hence, Bandicoot has not only revamped sanitation but also empowered the lives of more than 3,000 sanitation workers in 17 states and several union territories across India, ensuring their sustainable existence. Bandicoot has succeeded in achieving nine of the 17 Sustainable Development Goals (SDGs) of the United Nations. It comprises good health and well-being; quality education; clean water and sanitation; decent work and economic growth; industry, innovation, and infrastructure; reduced inequality; sustainable cities and communities; responsible consumption and production; and peace, justice, and strong institutions. Wilboar and G Beetle, two more Genrobotics products, also offer breakthrough technological advancement. Therefore, the main takeaway from all of these facts is that reliance on cutting-edge technology supported by robotics and artificial intelligence needs to be significantly utilized in order to ensure the advancement of a progressive nation like India, as it also aids in the attainment of sustainable development goals.

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Table 1. Information about deaths of people in septic tanks and sewers over the previous five years (2017 - 2021)

Sr. No.	Name of State/UT	Total Number of sewer death
1	Andhra Pradesh	13
2	Bihar	2
3	Chhattisgarh	1
4	Chandigarh	3
5	Delhi	42
6	Gujarat	28
7	Haryana	33
8	Karnataka	26





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9	Kerala	1
10	Maharashtra	30
11	Madhya Pradesh	1
12	Odisha	2
13	Punjab	16
14	Rajasthan	13
15	Tamil Nadu	43
16	Telangana	6
17	Uttar Pradesh	52
18	West Bengal	13
	Total	325

Source: PIB (2022, March 30). Scavengers in the country. Retrieved from [https:// pib.gov.in /PressReleaseIframePage.aspx?PRID=1811403](https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1811403)

Table 2. State-wise number of manual scavengers

Sr. No.	Name of State/UT	No. of Manual Scavengers
1	Andhra Pradesh	1793
2	Assam	3921
3	Bihar	131
4	Chhattisgarh	3
5	Gujarat	105
6	Jharkahand	192
7	Karnataka	2927
8	Kerala	518
9	Madhya Pradesh	510
10	Maharashtra	6325
11	Odisha	230
12	Punjab	231
13	Rajasthan	2673
14	Tamilnadu	398
15	Uttar Pradesh	32473
16	Uttarakhand	4988
17	West Bengal	680
	Total	58098

Source: PIB (2022, March 30). Scavengers in the country. Retrieved from <https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1811403>





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Figure 1. Manual Scavenger
 Source: The Indian Express, New Delhi Edition
 retrieved from
<https://indianexpress.com/article/india/athawale-in-parliament-73-31-of-manual-scavengers-from-scheduled-castes-7653092/>



Figure 2. Genrobotics Founder Members
 Source: https://images.cnbcv18.com/wp-content/uploads/2022/07/Genrobotic_1.jpg

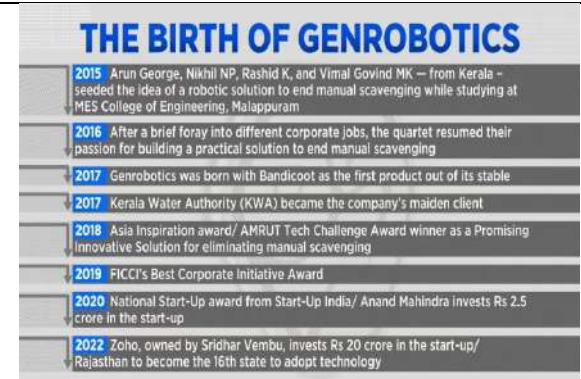


Figure 3. The Birth of Generobotics
 Source: https://images.cnbcv18.com/wp-content/uploads/2022/07/Genrobotic_4.jpg



Figure 4. Bandicoot
 Source: <https://www.genrobotics.org>



Figure 5. Manufacturing of Bandicoot
 Source: <https://www.genrobotics.org>



Figure 6. Bandicoot Key Features
 Source: https://images.cnbcv18.com/wp-content/uploads/2022/07/Genrobotic_3.jpg





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Figure 7. Bandicoot State-wise Adoption Chart

Source:https://images.cnbcvt18.com/wp-content/uploads/2022/07/Genrobotic_2-1019x573.jpg





Solubility and Dissolution Rate Enhancement of Ticagrelor and Development of Fast Dissolving Tablets

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ABSTRACT

The aim of the present work is to enhance the solubility and dissolution rate of poorly soluble drug, Ticagrelor by formulating as solid dispersions. The solid dispersions were formulated with Gelucire 50/13, poloxamer-P188 and Kollidon VA64 as carriers. The kinetics and mechanisms of drug release from in-vitro dissolution parameters were calculated. The solid dispersions TPFM2 and TGFM2 in the drug: polymer ratio of 1:2 prepared by fusion method showed rapid drug release when compared to the pure drug. Further the optimized dispersions are used for preparation of fast dissolving tablets using different super disintegrants like Croscarmellose sodium and Sodium Starch Glycolate by direct compression technique. The prepared formulations were evaluated for physical parameters such as weight uniformity, hardness, friability, disintegration time and drug content & in vitro drug release. It was found that the formulation F7 and F13 with SSG at 15% showed the rapid drug release when compared to marketed and other tablet formulations. A drug release of tablet formulations in the presence of various super disintegrants were in the order of SSG>CCS.

Keywords: Solid Dispersion, Ticagrelor, Superdisintegrants, Poloxamer –188, Gelucire 50/13.





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INTRODUCTION

Although various novel and advanced drug delivery systems have been introduced for therapeutic use, the popularity of oral dosage forms particularly tablets have not been eclipsed, because of its numerous advantages. [1] However in case of the oral route there are several challenges such as limited drug absorption resulting in poor bioavailability and poor pharmacological response resulting into inadequate and erratic oral absorption. Drug absorption from the gastrointestinal (GI) tract can be limited by a variety of factors with the most significant contributors being poor aqueous solubility and/or poor membrane permeability of the drug molecule. When delivering an active agent orally, it must first dissolve in gastric and/or intestinal fluids before it can then permeate the membranes of the GI tract to reach systemic circulation. Therefore, a drug with poor aqueous solubility will typically exhibit dissolution rate limited absorption and a drug with poor membrane permeability will typically exhibit permeation rate limited absorption. Hence, two areas of pharmaceutical research that focus on improving the oral bioavailability of active agents include enhancing solubility and dissolution rate of poorly water-soluble drugs and enhancing permeability of poorly permeable drugs. This article focuses on the former, in particular, the use of solid dispersion [2] and fast dissolving/disintegrating tablets (FDDTs) technologies to improve the dissolution characteristics of poorly water-soluble drugs and in turn their oral bioavailability. Hence, fast dissolving/disintegrating tablets (FDDTs) are a perfect fit for them. FDDTs dissolves or more commonly disintegrate rapidly in the saliva without the aid of water.[3]Ticagrelor is used for the prevention of thrombotic events in people with acute coronary syndrome or myocardial infarction with ST elevation.[4]The aim of the work is to enhance the solubility, dissolution rate and oral bioavailability of poorly soluble drug, Ticagrelor by formulating as solid dispersions using fusion method with Gelucire 50/13, Poloxamer-P188 and Kollidon VA64 and subsequent preparation of fast dissolving tablets from solid dispersions using different superdisintegrants and comparing them with that of the marketed product.

MATERIALS AND METHODS

Ticagrelor was obtained as Gift sample from NATCO, Hyderabad. KollidonVA64 Poloxamer P188 and Gelucire 50/13 were obtained as Gift sample from NATCO, Hyderabad. Sodium Starch Glycolate and Croscarmellose sodium was commercially obtained from S.D Fine Chem, Ltd., Mumbai.

Saturated Solubility Studies

Saturated solubility studies of Ticagrelor were performed in different dissolution media. 200mg of Ticagrelor was weighed and transferred into different conical flask. 25ml of different dissolution media i.e., 6.8 pH phosphate buffer, 7.4 pH phosphate buffer, 0.1N HCl, 0.2% Tween 80 and Distilled water were transferred into individual conical flask and were closed appropriately.[5]All the conical flasks were placed in the REMI incubator shaker. The shaker was allowed to operate at 50 rpm at $37^{\circ}\text{C} \pm 1^{\circ}\text{C}$ for 48 hrs. Then the conical flasks were removed from the incubator shaker and the samples were filtered by using Whattmann filter paper. The clear solution obtained by filtration was suitably diluted with appropriate dissolution media and the absorbance values were noted at 296 nm by using corresponding dissolution media as blank solutions. The saturated solubility studies indicated that ticagrelor showed maximum solubility in 0.2% Tween 80 in distilled water.

PREPARATION OF TICAGRELOR SOLID DISPERSIONS

Solid dispersions were prepared by using Poloxamer P188, Gelucire 50/13 and Kollidon VA 64 as carriers by employing fusion method for the preparation of solid dispersions. Specified quantity of carrier was taken in a china dish and subjected to melting by keeping china dish on hot plate. After melting of carrier, specified quantity of drug was added to this melted carrier. Soon after incorporation of drug in to the carrier, the china dish was kept a side for 24 hrs. Then after collect solid dispersion and stored hermetically in desiccator. The composition of various solid dispersions was given in table 1.





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Evaluation of Solid Dispersions: The prepared solid dispersions were evaluated for various pre formulation parameters such as angle of repose, Carr's index and Hausner's ratio.[6]The results were given the table 2.

In-Vitro Dissolution Studies of Ticagrelor Solid Dispersions

The dissolution studies for the solid dispersions was carried out in USP Apparatus Type II (paddle)with 900 ml of 0.2% tween 80 as the dissolution medium. The samples were drawn at 5, 10, 15, 30 and 45 minutes. Fresh volume of the medium was replaced with the withdrawn volume to maintain the sink conditions and constant volume throughout the experiment. Samples withdrawn were suitably diluted with same dissolution medium and the amount of drug dissolved was estimated by ELICO SL-210 double beam spectrophotometer at 296nm and subsequently analyzed for the cumulative percentage of drug released. The dissolution profiles of ticagrelor solid dispersions were shown in the figures 1&2. Based on the dissolution studies performed on all the formulations, some of the optimized solid dispersions were selected and further characterized by FT-IR and XRD studies[7]. FT-IR and XRD patterns were shown in the figures 3,4.

Development of Ticagrelor Fast Dissolving Tablets From Solid Dispersions

Preparation of Ticagrelor Fast Dissolving Tablets

Among the solid dispersion prepared and based up on dissolution studies performed, Solid dispersions prepared by Fusion method containing Drug:Poloxamer and Drug: Gelucire 50/13 in the ratio of 1:2 were optimized for further preparation of fast dissolving tablets. The tablet was prepared by direct compression process. The tablet formulation consists of Solid dispersion, superdisintegrant, diluent and anti frictional agents. The ratio of drug: carrier was maintained constant while the superdisintegrant concentration was varied.[8]The composition of various tablet formulations were given in table 3. Physical parameters such as weight variation, friability, hardness, disintegration and drug content were evaluated for the prepared tablets.The results were shown in table 4.

In-Vitro Dissolution Studies of Ticagrelor Fast Dissolving Tablets.

The formulated tablets were also further evaluated for drug content, for *in vitro* drug release studies. [9]The dissolution test was carried out in USP Apparatus Type II (paddle) with 900ml of 0.2% tween 80 as the dissolution medium. The samples were drawn at 5, 10, 15, 30 and 45 minutes.The amount of drug dissolved was estimated by ELICO double beam spectrophotometer at 296 nm and subsequently analyzed for the cumulative percentage of drug released[10,11]The drug release profiles for all the formulations were shown in figures 5,6.The comparative drug release profiles of optimised ticagrelor tablet formulations with marketed formulation were given in the figure 7.

Similarity and Difference Factor of Tablet Formulations

The dissolution profiles of F7 and F13 tablet formulations were compared with marketed Ticagrelor tablets.[12]The difference factor (f1) and similarity factor (f2) of formulations results were given in the table 6.

Accelerated Stability Data of Tablet Formulations

Accelerated stability studies were performed for the optimized formulations (F7 and F13). The product was subjected to accelerated stability studies at 40°C±2°C/75% ±5% RH for 60days.There were no significant changes observed in drug release from the tablets after storage at different conditions[13] remained unaltered and found to be quite stable and the results were shown in the figure 8 and 9.

DISCUSSION OF RESULTS

The spectrophotometric method used for estimation of Ticagrelor in 0.2% tween 80 in distilled water was found to be linear and reproducible. The saturated solubility studies for pure drug was carried out in different media. The studies indicated that Ticagrelor showed maximum solubility in 0.2% tween 80 in distilled water. Solid dispersions of Ticagrelor drug were prepared by Fusion method by using Poloxamer P188, Gelucire 50/13 and Kollidon VA 64 as polymers. The dispersions were evaluated for angle of repose and Carr's index and for drug content. The angle of



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repose values obtained for various solid dispersions were in the range of 13^0 - 23^0 . Carr's index values obtained for various solid dispersions were in the range of 9 – 17%. Particle sizes of prepared solid dispersions were found to be in the range of 172 – 179 μm . The drug content of prepared solid dispersions was found to be in the range of 88.58–89.8 mg. The *in vitro* dissolution studies were performed for various solid dispersions in 0.2% tween 80 in distilled water. It was found that the solid dispersions TPFM2 and TGFM2 in the drug:polymer ratio of 1:2 by employing poloxamer P188 and gelucire 50/13 prepared by fusion method shows rapid drug release when compared to the pure drug. The optimized solid dispersions were selected and further investigated for FTIR, DSC and PXRD. IR studies of Ticagrelor and optimized formulations were carried out to study the interaction between the drug and excipients used. N-H stretching, R-COOH stretching, C=N stretching and fluoride of pure Ticagrelor and the optimized formulations were almost in the same. It showed that IR spectrum of Ticagrelor and optimized formulations were having similar fundamental peaks and pattern. Powder X-ray diffraction (PXRD) patterns were traced employing X-ray diffractometer Bruker AXS, DH Advance, Germany for all the samples.

The solid dispersions that shows rapid dissolution when compared to pure ticagrelor was further selected for the preparation of fast dissolving tablets. The fast dissolving tablets were prepared by using superdisintegrants like CCS and SSG at various concentrations. The compressed tablets were further evaluated for physical parameters such as weight uniformity, hardness, friability, drug content and disintegrating time. All the physical parameters evaluated were with the specified limits. The direct compression process was found to be suitable for compressing optimized solid dispersions as fast dissolving tablets dissolution studies were prepared on all the tablet formulations by using USP type II apparatus (paddle). Among the formulations prepared the formulations F7 and F13 prepared by using solid dispersions Poloxamer P188 and Gelucire 50/13 and with 15% SSG as superdisintegrant were found to release the drug rapidly than other formulations. The dissolution profiles of F7 and F13 tablet formulations were compared with marketed Ticagrelor tablets. The difference factor and similarity factor were calculated for these tablet formulations. The difference factor f_1 values are 9 and 12 and similarity factor f_2 values are 54 and 60. The formulations F7 and F13 showed the similarity factor values above 50 indicated that the release profiles for these formulations were similar to that of marketed formulation. The optimized fast dissolving tablet formulations were subjected to accelerated stability studies. These formulations were stored at $40^\circ\text{C}\pm 2^\circ\text{C}$, $75\%\pm 5\%$ RH for 6 months. Then after storage these formulations were evaluated for the physical parameters like weight uniformity, hardness, friability and drug content. There were no significant changes observed in drug release from the tablets after storage at different conditions remained unaltered and found to be quite stable.

CONCLUSION

In the present study an attempt was made to improve solubility and dissolution rate of Ticagrelor by solid dispersions technique with carriers like Poloxamer P188, Gelucire 50/13 and Kollidon VA 64. It was found that the solid dispersions prepared by Poloxamer P188 and Gelucire 50/13 employing fusion method in the ratio of 1:2 showed rapid drug release when compared to the pure drug. The direct compression process was found to be suitable for compressing optimized solid dispersions as tablets. The formulation F7 & F13 with Sodium Starch Glycolate at 15% showed the rapid drug release when compared to other tablet formulations. It may be concluded that Ticagrelor tablets prepared by using solid dispersions with 15% SSG was found to be ideal formulation.

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Table 1: Composition of various solid dispersions of Ticagrelor by fusion method.

S. No	Composition	Ratio
Drug: Poloxamer P188		
1	TPFM1	1:1
2	TPFM2	1:2
Drug: Gelucire 50/13		
3	TGFM1	1:1
4	TGFM2	1:2
Drug: Kollidon VA 64		
5	TKFM1	1:1
6	TKFM2	1:2

Table 2: Evaluation of Ticagrelor Solid Dispersions

S.No	Solid Dispersion	Angle of repose (°)	Carr's Index(%)	Particle size (microns)	Drug Content (%)
01	TPFM1	23.21	17.23	176±2	99.95±0.3





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02	TPFM2	21.45	14.56	175±4	97.35±0.9
03	TGFM1	19.85	13.77	173±3	98.20±1.1
04	TGFM2	19.22	13.25	177±2	99.15±0.5
05	TKFM1	18.65	11.14	178±2	97.35±2.1
06	TKFM2	16.52	13.64	176±5	97.10±1.5

Table 3: Compositions of Ticagrelor Fast Dissolving Tablet Formulations

Formulations	Ingredients								
	TPD(mg)	TPFM2 (mg)	TGFM2 (mg)	CCS (mg)	SSG (mg)	MCC Avicel pH 102	Mg. Stearate (mg)	Talc (mg)	Total weight (mg)
F1	90	-	-	-	-	355	2.5	2.5	450
F2	-	270	-	45	-	130	2.5	2.5	450
F3	-	270	-	67.5	-	107.5	2.5	2.5	450
F4	-	270	-	90	-	85	2.5	2.5	450
F5	-	270	-	-	45	130	2.5	2.5	450
F6	-	270	-	-	67.5	107.5	2.5	2.5	450
F7	-	270	-	-	90	85	2.5	2.5	450
F8	-	-	270	45	-	130	2.5	2.5	450
F9	-	-	270	67.5	-	107.5	2.5	2.5	450
F10	-	-	270	90	-	85	2.5	2.5	450
F11	-	-	270	-	45	130	2.5	2.5	450
F12	-	-	270	-	67.5	107.5	2.5	2.5	450
F13	-	-	270	-	90	85	2.5	2.5	450

Table 4: Evaluation of Ticagrelor Fast Dissolving Tablet Formulations

S. No	Formulation	Weight uniformity (mg)	Hardness (kg/cm)	Friability (%)loss	Drug Content (mg/tablet)	Disintegration time (Sec)
1	F1	449 ± 3	3.5 ± 0.3	0.16	89.10 ± 0.2	120
2	F2	448 ± 3	3.5 ± 0.4	0.17	89.10 ± 0.2	70
3	F3	450 ± 4	3.5 ± 0.3	0.16	89.64 ± 0.2	110
4	F4	449 ± 3	3.5 ± 0.2	0.16	89.90 ± 0.3	110
5	F5	451 ± 2	3.5 ± 0.3	0.18	89.74 ± 0.3	80
6	F6	449 ± 3	3.5 ± 0.3	0.17	89.82 ± 0.4	97
7	F7	449 ± 3	3.5 ± 0.3	0.16	89.10 ± 0.2	112
8	F8	448 ± 3	3.5 ± 0.4	0.17	89.10 ± 0.2	106





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9	F9	450 ± 4	3.5 ± 0.3	0.16	89.64 ± 0.2	83
10	F10	449 ± 3	3.5 ± 0.2	0.16	89.90 ± 0.3	80
11	F11	450 ± 2	3.5 ± 0.3	0.18	89.74 ± 0.3	92
12	F12	449 ± 3	3.5 ± 0.3	0.17	89.82 ± 0.4	97
13	F13	449 ± 3	3.5 ± 0.3	0.18	89.74 ± 0.3	85

Table 5: Evaluation of Drug Release Parameters of Ticagrelor Tablets

FORMUALTION	% Drug released at 30 mins	T ₅₀ (min)	DE 30%	Zero order		First order		Hixon Crowell	
				R ²	K(mg)	R ²	K(min ⁻¹)	R ²	K (mg ^{1/3})
TMF	85.03	14	45.00	0.897	1.884	0.983	0.044	0.959	0.046
F1	53.16	32	25.83	0.900	1.186	0.966	0.017	0.022	0.959
F2	80.12	18	36.66	0.901	1.787	0.990	0.037	0.042	0.987
F3	90.06	16.5	40.00	0.900	1.965	0.992	0.051	0.053	0.997
F4	91.54	16	45.00	0.901	1.991	0.993	0.055	0.056	0.995
F5	90.28	14	43.33	0.900	2.028	0.991	0.052	0.054	0.983
F6	96.25	13	45.00	0.902	2.109	0.967	0.071	0.065	0.989
F7	97.50	12.5	50.83	0.901	2.120	0.953	0.079	0.069	0.987
F8	87.08	17.5	37.50	0.899	1.943	0.989	0.046	0.053	0.995
F9	89.19	17	38.33	0.898	1.970	0.988	0.049	0.052	0.998
F10	89.97	15.5	41.66	0.899	1.937	0.992	0.050	0.052	0.998
F11	93.21	14.5	43.33	0.900	2.097	0.979	0.059	0.059	0.985
F12	95.20	14	45.00	0.901	2.112	0.977	0.066	0.063	0.988
F13	95.30	13.5	46.66	0.899	2.088	0.977	0.066	0.063	0.990

Table 6: Similarity and Difference Factor Results of Optimized Ticagrelor Tablet Formulations (F6, F7 and F13).

Formulations	f1 Difference Factor	f2 Similarity Factor
F7	12	54
F13	9	60





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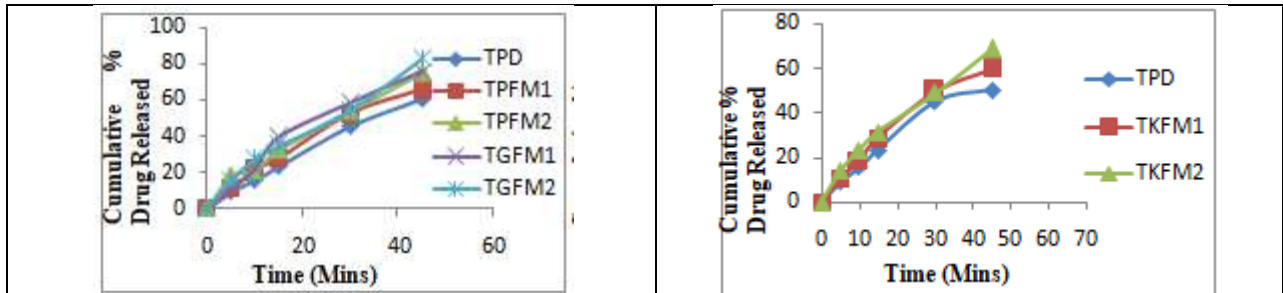


Figure 1 & 2 : Drug Release Profiles of Ticagrelor Solid Dispersions TPFM1, TPFM2; TGFM1 and TGFM2 ; TKFM1 and TKFM2 Prepared by Fusion method

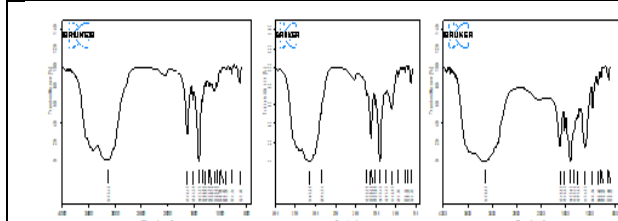


Figure 3: IR Interpretations of (a) TPD (b) TPFM2 (c) TGFM2

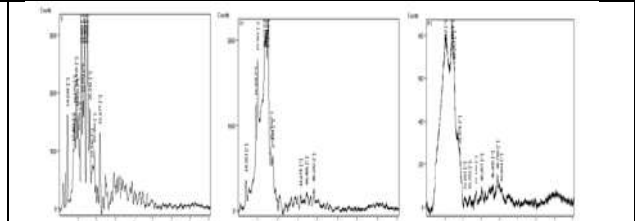


Figure 4: Powder X-ray Diffraction (PXRD) patterns for (a) TPD (b) TPFM2 (c) TGFM2

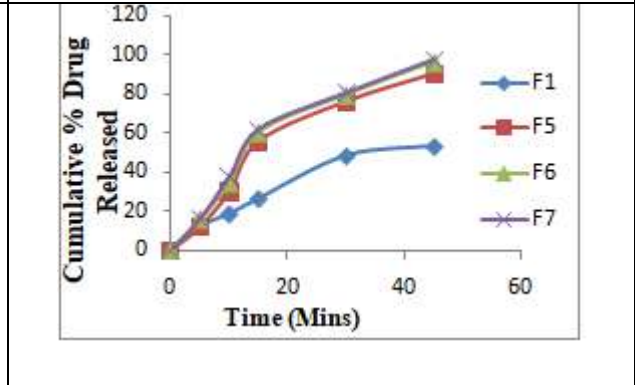
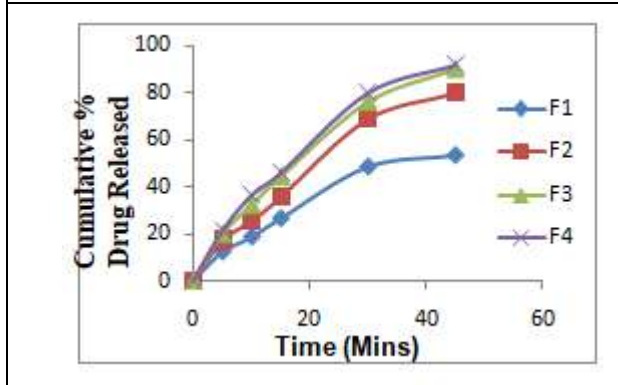


Figure 5: Drug Release Profiles of Ticagrelor Tablet Formulations using TPFM2 Solid dispersions with Croscarmellose Sodium and Sodium Starch Glycolate.

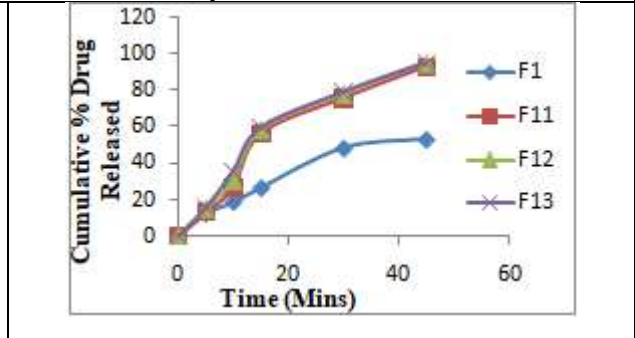
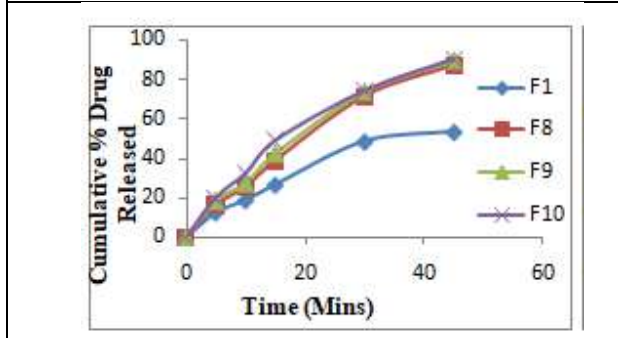
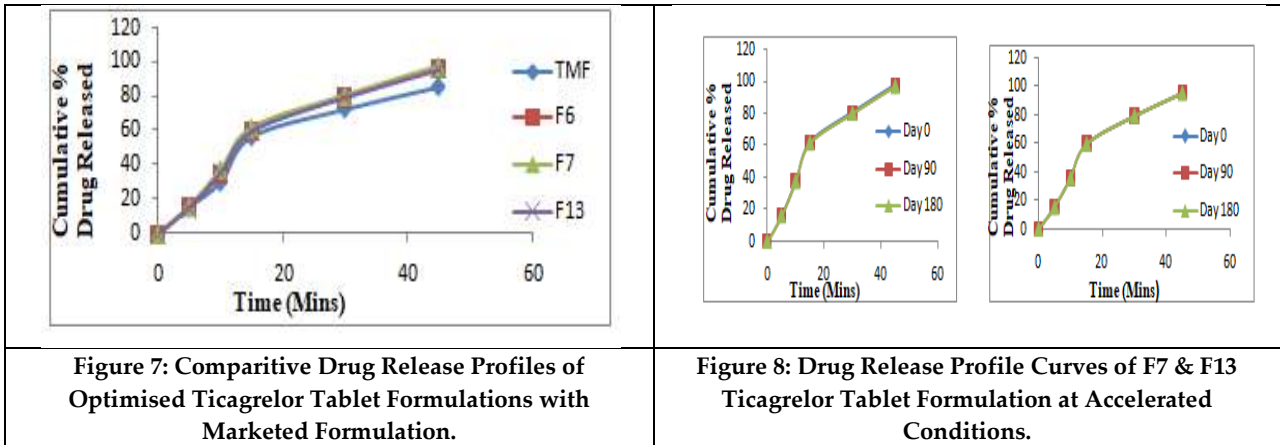


Figure 6: Drug Release Profiles of Ticagrelor Tablet Formulations using TGFM2 Solid Dispersions with Croscarmellose Sodium and Sodium Starch Glycolate





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Traffic Control and Shortest Path

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ABSTRACT

Urban areas worldwide face a mounting challenge in the form of traffic congestion, necessitating innovative solutions to augment transportation efficiency. This study presents an approach through the integration of an advanced traffic control system and shortest path optimization, incorporating real-time traffic density estimation. Leveraging Reinforcement Learning (RL), specifically the Improved Deep Q-Network (IDQN) algorithm, the research adaptively manages traffic flow by synthesizing insights from an Improved Single Shot Detector (ISSD) algorithm. The developed system dynamically adjusts traffic signal timings and recommends optimal routes by learning from real-time density metrics. Through continuous interaction with the urban environment, RL agents evolve optimal control policies that strike a delicate balance between minimizing travel time and maximizing traffic flow efficiency. Rigorous experiments conducted in realistic scenarios showcase significant reductions in congestion and substantial improvements in route optimization. This research presents a unified framework, unifying RL and real-time traffic density estimation, contributing substantially to intelligent transportation systems.

Keywords: Traffic Density Estimation, Shortest Path, RL, SSD, DQN





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INTRODUCTION

The enormous rise in the number of automobiles on roadways is a major challenge to urban transportation systems across the globe [1]. This is a direct result of urbanization and population expansion. Continued urbanization has a negative impact on residents' quality of life in addition to causing significant economic losses [2]. In order to overcome this obstacle, we need creative strategies to increase transportation effectiveness and decrease traffic [3]. When it comes to dynamically adjusting to the ever-changing traffic patterns of metropolitan areas, traditional approaches of traffic management, although useful to a certain degree, typically fall short [4-5]. This study is groundbreaking because it combines cutting-edge traffic management systems with shortest route optimization methods [6-7] to reduce traffic congestion in metropolitan areas. The employment of real-time traffic density estimate is crucial to this cutting-edge technology since it gives vital insights into the present status of traffic on road networks [8-9]. The study's ultimate goal is to revolutionize traffic management and route optimization techniques by using this real-time data to make them more flexible, efficient, and sensitive to the ever-changing nature of urban traffic [10, 11]. The central tenet of this investigation is the use of Reinforcement Learning (RL), a potent paradigm in AI, for efficient traffic management [12, 13]. The system is able to learn optimal control policies through persistent interaction with the urban environment thanks to RL algorithms, in particular the Deep Q-Network (DQN) [14].

These algorithms can dynamically adjust traffic signal timings and recommend optimal routes by analyzing real-time density metrics [15]. The proposed system seeks to significantly reduce congestion and improve route optimization in urban areas [16] by striking a balance between minimizing travel time and maximizing the efficiency of traffic flow. Through rigorous experimentation in realistic scenarios, this research aims to demonstrate the effectiveness of the integrated system in significantly reducing congestion and optimizing travel routes. We anticipate that this study's findings will provide a cohesive foundation for intelligent transportation system development by integrating RL approaches with real-time traffic density estimates [17-18]. With this structure in place, urban transportation might be improved, making it more efficient, adaptable, and long-term viable in the midst of rising traffic and fast urbanization. In order to build smarter and more efficient urban settings, novel approaches are essential, such as the one offered in this study, which is especially important since cities undergo continuous change [19-20]. DQN, a type of deep reinforcement learning, is able to reliably predict traffic density in dynamic urban settings as it constantly adjusts its parameters through trial and error [21]. This system provides real-time estimates of traffic density, allowing traffic management systems and authorities to make data-driven decisions, optimize traffic signal timings, and improve overall traffic flow, ultimately leading to more efficient and responsive urban transportation networks [22-23]. The remaining sections of this work are organized as follows. In Section 2, a background study of various researches on estimating traffic density using CNN, DQN, and SSD has been discussed. Section 3 presents the suggested model and the findings are given in Section 4 and conclusion is presented in Section 5.

Motivation of the paper

This study offers a groundbreaking solution to urban traffic congestion by integrating advanced traffic control and real-time traffic density estimation using Reinforcement Learning (RL). Through innovative algorithms and adaptive traffic management, the research significantly reduces congestion, improves route optimization, and contributes substantially to intelligent transportation systems. The system's adaptability to diverse traffic conditions positions it as a robust and efficient solution, concrete the way for smarter, sustainable urban mobility and responsive urban environments.

Background study

In order to forecast highway traffic density, A. Agarwal et al. [1] proposed a modern CNN paradigm. The author used a max pooling layer and a batch normalized layer to enhance the model's accuracy. Images taken from three different traffic films have been used to evaluate the concept. 30 epochs of data were collected for examination of accuracy and loss. With these factors in mind, the author evaluates the suggested technique against an alternative





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CNN model. Additional datasets with restrictions such as lighting and occlusion can be taken into account in the future. To find the traffic conjunction on the signal G. T. Prabavathi and M. Kavitha [5] presented ISSD-YOLOV4 hybrid neural network architecture. The objective of this study is to generate a high-quality vehicle density using the network-based combination of extracted features from low-resolution feature maps. We evaluated the experimental research accuracy with the following models: TV networks include CNN, SPPNET, YOLOV3, YOLOV4, and SSD . The final result of the research showed that YOLOV4 and ISSD gave a better accuracy than the above mentioned models. M. Kavitha and G. T. Prabavathi [12] attempted to review the Intelligent Transportation Systems Safety and Challenges in cyber security of ITS. M. Kavitha and G. T. Prabavathi [13] reviewed the various algorithm in RL DL for traffic signal control and intelligent transportation.

Problem definition

Congestion in metropolitan areas is a prevalent problem that this research aims to alleviate. Rapid urbanization and increased vehicle usage have led to significant challenges in transportation efficiency. Traditional traffic management methods are often insufficient to handle the complexity of modern urban environments. This research aims to tackle this problem by devising solution that integrates advanced traffic control, real-time traffic density estimation, and RL techniques. By optimizing traffic signal timings and recommending optimal routes based on real-time data, the study addresses the intricate challenges posed by congested urban transportation networks, ultimately aiming for more efficient and sustainable urban mobility.

MATERIALS AND METHODS

This section provides a detailed overview of the experimental setup, methods, and algorithms used (Improved DQN & Improved SSD) and the systematic process followed to conduct experiments in realistic scenarios. The traffic control and shortest path optimization through real-time traffic density estimation model flowchart is shown in Figure 1.

System & Energy model

Using the RL paradigm, and more specifically the DQN algorithm, the proposed system integrates an advanced traffic control system with shortest path optimization and real-time traffic density estimation. The real-time traffic density data which is the output from the Improved SSD algorithm is fed into RL agents. RL agents constantly interact with their surroundings and learn optimal control policies allowing for dynamic route recommendations and adaptive traffic flow management. Through shortest path optimization, the proposed system can show significant reduction in congestion in real-world scenarios by adjusting traffic signal timings and suggesting optimal routes based on real-time density metrics. The flexibility of this unified framework under varying traffic conditions makes it an effective answer to the complex problems facing urban transportation networks and paves the way for more responsive and sustainable city planning. The system optimizes traffic light timings and suggests alternate routes with an eye toward reducing fuel consumption in addition to improving travel time and traffic flow. The DQN algorithm used by RL agents constantly learn and interact with the urban environment to optimize traffic signals and routes in order to cut down on energy waste caused by sudden starts, stops, and idling. The system not only reduces congestion but also significantly lessens the carbon footprint associated with urban transportation by promoting smoother traffic flow and reducing energy-intensive traffic patterns.

Traffic Flow management using Improved SSD

The goal of the improved SSD is to detect real-time objects belonging to different classes in a single frame. The feature pyramid networks allow the Improved SSD to detect objects of varying sizes and scales within an image. One of the algorithm's most notable feature is its ability to detect small and large objects simultaneously. Aspect ratio clustering and anchor box refinement are two methods that have been incorporated in this research work. Algorithms can gain a deeper understanding of the shapes of objects they are detecting with the help of aspect ratio clustering, which groups objects with similar aspect ratios together. The aim of anchor box refinement is to adjust the





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predefined anchor boxes, which are utilized to predict object bounding boxes, in order to better align with the actual shapes of objects in the image, thereby enhancing the accuracy of object localization. During the training phase, SSD uses the Adam Optimizer to reduce the sum of the classification loss and the localization loss, which is the loss function being minimized. SSD performs classification using a multi-class softmax loss. Where Z is the number of default-boxes-to-background matches from equation 1.

$$L_{class}(Z, Z) = - \sum_{c=1}^i \sum_{i \in pros} z_{i,c} \cdot \log(Z_{i,c}) - \sum_{j \in neg} \log(Z_{j,\sigma}) \tag{1}$$

$$smooth_{\frac{1}{i}}(X) = \begin{cases} 0.5 \times x^2 & \text{if } |X| < 1 \\ |x| - 0.5 & \text{otherwise} \end{cases} \tag{2}$$

$$\sigma = [Z \ B + D] \tag{3}$$

As the object's exact bounding box, the probabilities in the L class read from the rows of the confusion matrix. Second, in each class, SSD performs ultimate detection with non-maximal suppression. Each recognized item is a tuple (class label, confidence score, bounding box coordinates).

Algorithm 1: Improved Single Shot Detector

Input: An image or a frame from a video feed that contains multiple objects belonging to different classes.

Steps:

1. **Feature Pyramid Network:**
To enable the identification of objects of different sizes and scales, use a feature pyramid network to extract multi-scale features from the input picture.
2. **Aspect Ratio Clustering:**

$$smooth_{\frac{1}{i}}(X) = \begin{cases} 0.5 \times x^2 & \text{if } |X| < 1 \\ |x| - 0.5 & \text{otherwise} \end{cases}$$
3. **Anchor Box Refinement:**

$$L_{class}(Z, Z) = - \sum_{c=1}^i \sum_{i \in pros} z_{i,c} \cdot \log(Z_{i,c}) - \sum_{j \in neg} \log(Z_{j,\sigma})$$
4. **Classification and Localization:**
 - Perform classification using a multi-class softmax loss function to predict class probabilities for each default box.
 - Compute the localization loss to minimize the discrepancy between predicted bounding boxes and ground truth boxes.

Output: List of detected objects along with their corresponding bounding boxes and class labels.

Traffic Density Estimation Using Improved DQN

Improved DQN combines real-time data collection with state-of-the-art machine learning techniques. Relevant features, such as vehicle count, speed, and spacing, are extracted and fed into a neural network by combining data from traffic cameras, sensors, and other sources. The DQN algorithm uses this neural network's ability to learn traffic density estimation patterns. The neural network that makes up a DQN is part of DQ Learning, which sidesteps the Q-table. The neural network's input states are action and Q-value pairs, so there is no need to map states to Q-values. In this case, DQN consists of Q-Network and Target-Q-neural networks. Since the Q-learning method relies on discrete states to generate the Q-table, it is affected by the Curse-of-Dimensionality problem. This problem is solved by DQ learning methods by approximating the Q-value function $Q(s, a)$ with an ANN.

$$L_i(\theta_i) = E(s, a) [Q * (s, a) - Q(s, a; \theta_i)]^2 \tag{4}$$

For every iteration, the goal Q value $Q[](s, a)$ is provided by

$$Q * (s, a) = E_s \ 0 \in S [R(s, a) + r \max_{a0} Q(s0, a0; \theta_{i-1} | s, a)] \tag{5}$$





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Where $Q(s', a')$ is the next state's Q-value computed using the previous iteration's Q-network weights, and $R(s, a)$ is the reward for the current state's action pair (s, a) gleaned from the environment.

$$Q(s, a) = E_{s' \sim p}[r + \gamma \max_{a'} Q(s', a') | s, a] \tag{6}$$

In this setting, deep neural networks can explain the car's behaviour based on the following parameters: r , the instantaneous reward received by state s after action a in states, p is the probability of a state transition, while γ is the discount factor. Therefore, the Q function is represented as a neural network, namely $q(s,a;\theta)$, where θ denotes the parameters of the network. Additionally, DQN defines the Q function $Q(s,a)$, where s is a 1:1 duplicate of the argument. Depicted in Equation 6 is the DQN's loss function. Equation 7 shows the DQN's loss function.

$$L(\theta) = E_{(s,a,r,s') \sim U}[(r + \gamma \max_{a'} Q(s', a'; \theta) - Q(s, a; \theta))^2] \tag{7}$$

The distribution in the experience replay buffer is denoted by U , and the experience tuple is derived by sampling in the buffer. Afterwards, the network parameters are updated using stochastic gradient descent to constantly minimize the loss function, as illustrated in the equation below.

$$\theta \leftarrow \theta - \alpha \nabla_{\theta} L(\theta) \tag{8}$$

In the context of vehicle obstacle avoidance training, the learning rate is used, but instead of updating the target network during training, the parameters are recycled after multistep training. Algorithm 2 shows the density estimation algorithm.

Algorithm 2: Density Estimation algorithm

Input: Real time continuous data from traffic image.

Steps: Deep Q-Network (DQN)

Q-Value Computation

$$Q(s, a) = E_{s' \sim p}[r + \gamma \max_{a'} Q(s', a') | s, a]$$

Loss Function Calculation

$$L(\theta) = E_{(s,a,r,s') \sim U}[(r + \gamma \max_{a'} Q(s', a'; \theta) - Q(s, a; \theta))^2]$$

Optimization:

Apply stochastic gradient descent to update the neural network parameters iteratively.

$$L(\theta) = E_{(s,a,r,s') \sim U}[(r + \gamma \max_{a'} Q(s', a'; \theta) - Q(s, a; \theta))^2]$$

Output:

Traffic Density: The output is a real-time estimation of traffic density in specific urban areas

RESULTS AND DISCUSSION

This section presents the outcomes of the experiments, providing insights into the effectiveness of the proposed methodology in addressing urban traffic congestion. Additionally, it discusses the implications of these results, highlighting the practical applications and significance of the research in the context of intelligent transportation systems. Figure 2 shows density estimation, flow estimation error, density estimation error, and parameters estimation error of CNN, DNN, RCNN and Improved DQN algorithms. The superiority of the proposed methodology becomes evident. The existing methods CNN, DNN and RCNN exhibit relatively higher errors across all parameters, indicating limitations in accuracy. In contrast, the proposed methodology significantly enhances performance. The traffic density estimation error reduces to 0.05, flow estimation error to 0.1, density estimation error to 0.15 and parameters estimation error to 0.2. These substantially lower error values demonstrate the effectiveness of the Improved Deep Q-Network in achieving more precise and reliable traffic density estimation, highlighting its potential for enhancing the accuracy and efficiency of urban traffic management systems.



**Kavitha and Prabavathi****CONCLUSION**

In the face of escalating urbanization and the resultant surge in vehicular traffic, this research has provided a transformative solution to one of the most pressing challenges of time and urban traffic congestion. By integrating RL through the DQN algorithm and real-time traffic density estimation, an efficient traffic management system has been designed. The outcomes of this experiments in real-world scenarios unequivocally demonstrate the efficacy of the proposed approach. The rigorous experiments conducted in realistic scenarios validate the efficacy of this unified framework, showcasing its potential to significantly enhance intelligent transportation systems in urban areas worldwide. Moving forward, continued research and implementation of such innovative solutions will be crucial in addressing the evolving complexities of urban mobility, paving the way for more sustainable and efficient transportation networks.

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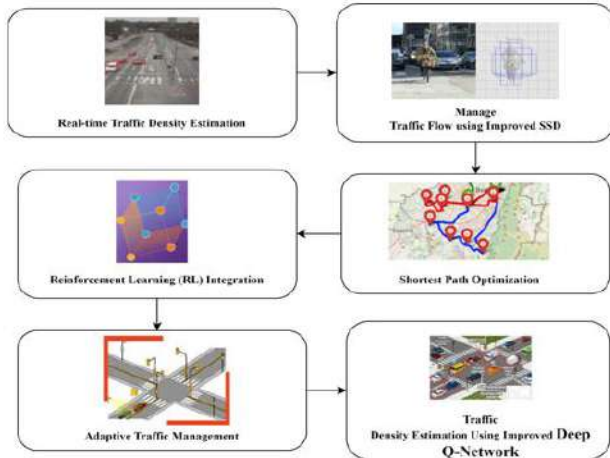


Figure 1: Overall architecture

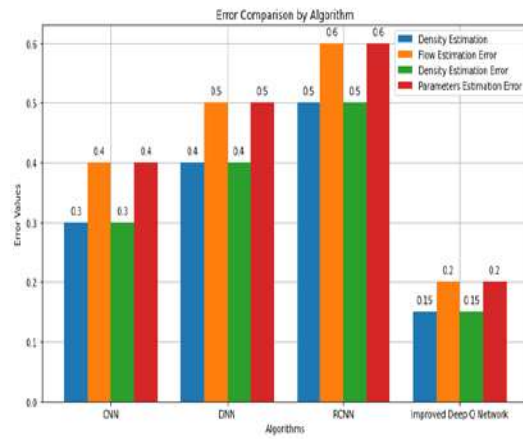


Figure 2: CNN, DNN, RCNN, Improved DQN comparison chart





Comparative Evaluation of Chemical Hair Dyes and Natural Hair Dyes and Their Effect on Normal Hair Flora

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ABSTRACT

Herbal hair dyes are commonly used as traditional way of coloring the hair. Traditional System may indicate safety, but not up to its efficacy, especially in herbal leaves where tradition is almost completely based on remedies containing active principles at very low and ultra-low concentrations, or relying on magical-energetic principles. The present study is on antimicrobial activity of 4 different herbal natural sources and chemical commercial dye on normal flora of hair. The maximum and minimum zone of inhibition 3nm & 2nm was observed against chemical dyes. The maximum and minimum zone of inhibition 1.7 nm & 1 nm was observed against was observed against herbal natural sources. Traditional herbal natural sources are very much good for maintaining the health of hair where it won't damage the normal flora of hair. Where the chemical dyes will damage the hair and also disturb the normal flora of hair. By these effects there will be allergic reaction on the scalp Governments, international agencies and corporations are increasingly investing in traditional herbal medicine research. Yet little literature





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addresses ethical challenges in this research. In this paper, we apply concepts in a comprehensive ethical framework for clinical research to international traditional herbal medicine research.

Keywords: Herbal, chemical, Hair- Dye, Normal Flora and Antimicrobial Activity.

INTRODUCTION

Herbs are natural products and their chemical composition varies depending on several factors and therefore varying from people to people, from energetic decoctions to the use of herbal extracts following Western methodologies of mainstream medicine. Traditional medicines has a very long history: it is the sum total of the practices based on the theories, beliefs and experiences of different cultures and times, often inexplicable, used in the maintenance of health, as like in the prevention, diagnosis, improvement and treatment of illnesses. In every country traditional medicine find foundation in magical or religious beliefs, or popular experience and the World Health Organization is engaged to establish definitive guidelines for methodology of clinical research and the appraisal of effectiveness of traditional medicine. To evaluate the efficacy, effectiveness and safety of a traditional herbal remedy. Traditional herbal medicines are naturally occurring, plant-derived substances with minimal or no industrial processing that have been used to treat illness within local or regional healing practices. Traditional herbal medicines are getting significant attention in global health debates. Cases like these present challenging questions related to the role of traditional herbal medicines in public health. People have been using natural dyes since ancient times for the purpose of dyeing carpets, rugs and clothing's by the use of roots, stems, barks, leaves, berries and flowers of various dye yielding plants [1]. In India, henna has been used traditionally for colouring palms and hairs. There are so many herbs like Kikar, Bihi, Bhringraj, Patnag, Akhrot, Narra, Jaborandi, Jatamansi, Amla, Kuth, Giloe, Behera which are used as a major constituent in hair care preparations mainly meant for dyeing hair [2 – 5]. In general, international research on traditional herbal medicines should be subject to the same ethical requirements as all research related to human subjects. An ethical framework previously outlined by Emanuel et al. Greying of hair is a natural phenomenon attributable to ageing and frequent use of synthetic shampoos which has encouraged application of synthetic dyes with the increase in the usage of hazardous chemicals in the process of manufacturing and revised for international research offers a useful starting point for thinking about the ethics of international traditional herbal medicine research. [6] This framework includes eight ethical requirements for clinical research These ethical requirements are universal and comprehensive but must be adapted to the particular social context in which the research is implemented. Of these, fair subject selection, independent review, informed consent, and respect for enrolled subjects have been discussed previously in the literature on the ethics of global health research and raise few issues unique to international traditional herbal medicine research. India is a country of vast bio-geographic diversity. Because of the country's diversified climatic and physiographic factors, India is blessed with all types of vegetation: tropical, subtropical, temperate, and alpine. Due to its wide-ranging environmental regimes and diverse biological communities, the country is one of the world's top 12 "mega diversity" nations. [7] However, social value, scientific validity, and favorable risk-benefit ratio raise specific challenges in international herbal medicine research that have not been adequately discussed.

MATERIALS AND METHODS

Collection of the sample

Firstly the samples of normal hair flora was collected from the human scarp and inoculated on to the nutrient agar media and sub-cultured it for further studies (Fig 1). Gram's staining was done to differentiate Gram positive and Gram-negative cell (Fig 2)





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Preparation of dye extracts

Herbal: 3 different fresh herbal leaves of *Lawsonia inermis* (Henna), *Aloe barbadensis miller* (Aloe-vera), *Eclipta prostrata* (Bhrinraj) and *Hibiscus rosa-sinensis* (Mandara-aku) were collected from the garden of St. Ann's Degree college for Women and brought to microbiology lab under sterile condition. Immediately the leaves were wash under running tap water separately. These leaves homogenised by using motor and pestle to make it into fine paste

Chemicals dye: Commercially Available godrej dye packet was purchased from a local market and made into paste form for further studies

Antimicrobial activity

Both nutrient and PDA media were prepared, inoculated with the normal flora culture samples which was collected previously by spread plate method under sterile conditions. Both herbal and chemical dye were loaded into the wells on the lawn culture plates (Fig 3) The antimicrobial activity was studied by using well diffusion plate method. The zone of inhibition was measured by using Vernier caliper (Fig 4).

Open Patch Test

Sensitizing the potential of formulation is to be tested. Hence a small quantity has been applied on the fore arm to check for any local reaction

RESULT AND DISCUSSION

Herbal dyes give maintain the health of hair with any damage to the hair as well as normal flora of scalp. Their antimicrobial activity was mainly because of compound that are naturally synthesized by the plant. There was a lot of difference in the effect of herbal and chemical dyes on normal flora. In the present study four different colonies were observed after incubation. Two Gram positive and Gram-negative cells were identified by Gram staining (Table 1, Fig 5). The range of antibacterial activity ranges from 1.0nm to 1.7nm by the herbal dye and 2.0 nm to 3.0nm by chemical dyes (Table 2). Now-a-days gray hair was a big problem for the people. so, people are preferring chemical dyes to color their hair. But the chemicals like phenylenediamine and P-phenylenediamine showing chemical reactions on the normal flora of scalp and also leading to skin allergies. The herbal leaves are in their bioactive compound which are naturally synthesized will not disturb the normal flora of scalp. Herbal dye maintains the health of hair and color will remain for long period of time. By open patch test there was a local reaction by the chemical dye like irritation and erythema within three hours of application where there is no such type of reactions

CONCLUSION

The present study evaluates the formulation of organic hair dye comprising a mixture of powdered plant materials having natural products useful for dyeing the hair. It is evident from the results that this formulation is highly effective at slightly alkaline pH without causing hair damage and skin irritation. A fixative Iron filing with these powders gives darker and stable shade preferred in hair dyeing. Efficacy data shows that all these active constituents have prolonged dyeing effect on hair. The surfactant used cause dry scalp and loss of fat under the skin, which enhances the drying and damage of the hair follicle, thus hair fall starts. Advantage of this formulation is that the plant pigments penetrate into the cortex region without rupturing the hair follicles.



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Table 1: The result of Gram staining of four different colonies & microscopic images

Color of the colony	Gram Staining
1 White Rough Colony	Gram positive
2. Yellow colony	Gram negative
3. Orange colony	Gram negative
4. White Smooth Colony	Gram positive

Table 2 Anti-bacterial activity (nm) of herbal leaves

Name of the herbal leaves	White Rough Colony	Yellow Colony	Orange Colony	White Smooth colony
1. <i>Aloe barbadensis miller (Aloe-vera)</i>	1.2nm	1.4nm	1.7nm	1.3nm
2. <i>Lawsonia inermis (Henna)</i>	1.1nm	1.6nm	1.2nm	1.7nm
3. <i>Hibiscus rosa-sinensis (Mandara-aku)</i>	1.0nm	1.2nm	1.0nm	1.3nm
4. <i>Eclipta prostrata (Bhrinraj)</i>	1.4nm	1.3nm	1.3nm	1.6nm
5. Chemical dye (Godrej powder)	3nm	2.8nm	2.5nm	2.0nm



Fig: 1 Sub-cultured tubes of normal flora





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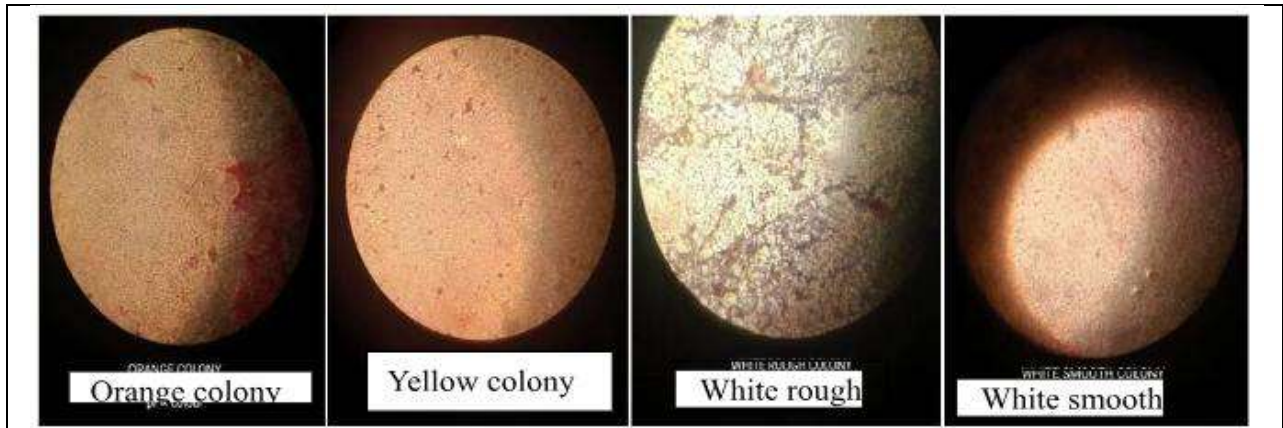


Fig 2: Gram staining of different colonies of normal flora



Fig 3: Inoculating the normal flora culture on to the media by spread plate method

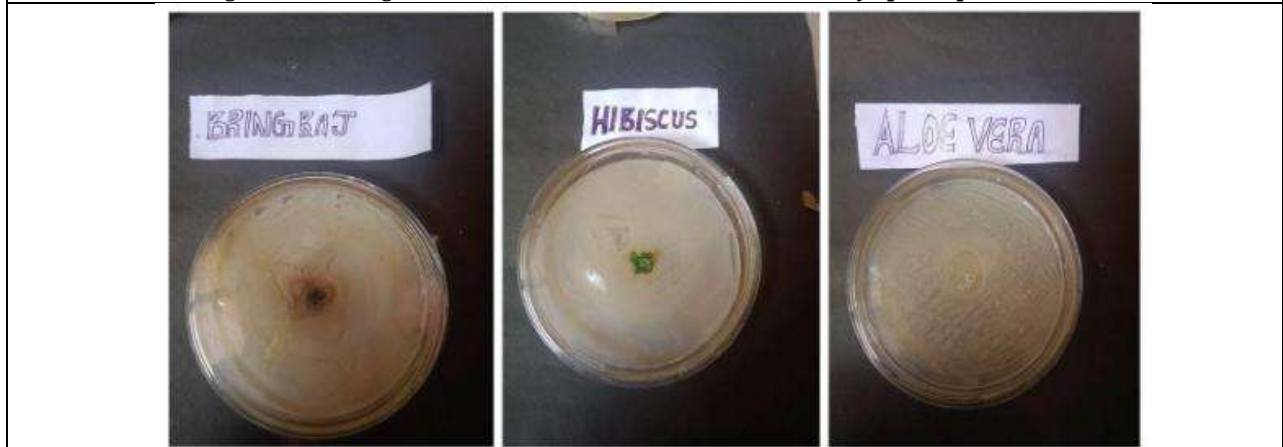


Fig 4: Aseptic loading of herbal paste in the well of cultured plates





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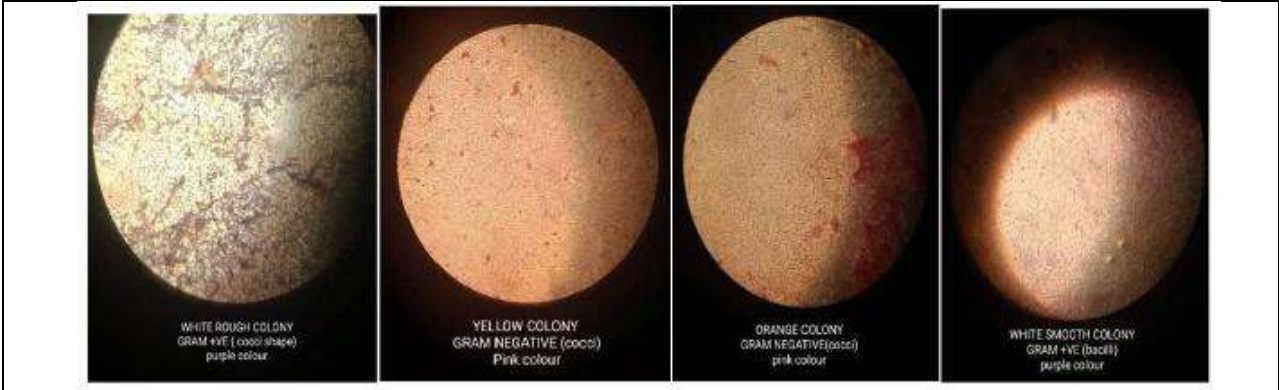


Fig.5. four different colonies



Fig 5. Measuring the zone of inhibition by using Vernier caliper





Immediate Effect of Intercostal Stretch and Pursed Lip Breathing Exercise on Thoracic Expansion and Pulmonary Function on Mild to Moderate COPD Subjects – A Comparative Study

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ABSTRACT

In the emerging countries, COPD is the most common pulmonary diseases, as a persistent reduction of lung airflow that interferes with normal breathing and is not entirely reversible. COPD is the third most common cause of death worldwide. It is multifactorial and Inhalational exposures to substances such as tobacco consumption, cigarette smoke, genetic risk factors, and work-related dusts and chemicals are frequently cited as risk factors. **Aim:** To compare the immediate effect of intercostal stretch along with thoracic expansion exercise and pursed lip breathing along with thoracic expansion exercise on pulmonary function and thoracic expansion on mild to moderate COPD subjects. 60 subjects were included in the study according to inclusion and exclusion criteria. subjects with mild to moderate COPD were randomly divided into 2 groups on the basis of the cheat method. 30 subjects were included in Group A received Intercostal Stretch Along with Thoracic Expansion Exercise. 30 subjects were included in Group B received Pursed Lip Breathing Along with Thoracic Expansion Exercise. outcome measures were PFT and CHEST EXPANSION measured pre-post intervention. Pre measures of mean values for Group A for FVC, FEV1, FEV1/FVC were 1.95,1.23,62.89 and the post measures were 2.14,1.60,77.38 respectively. The p-value for FVC, FEV1, FEV1/FVC was 0.000. The pre measures of mean values for Group B for Group B for FVC, FEV1, FEV1/FVC were 1.77,1.03,57.99 and the post measures were 1.83,1.22,66.39 respectively. The p-value for FVC was 0.05 and for FEV1, FEV1/FVC was 0.000. The pre measures of mean values for Group A for Axillary level, nipple level, xiphisternal level were 1.21,1.68,2.06 and post measures were 2.23,2.78,3.26 respectively. The p- value for Axillary level, nipple level, xiphisternal level was 0.000. The pre measures of mean values for Group B for Axillary level, nipple



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level, xiphisternal level were 1.23,1.48,1.85 and post measures for Axillary level, nipple level, xiphisternal level were 2.11, 2.55, 3.02 respectively. The p- value in both the groups for pre and post measures was found out to be <0.05. The mean scores for Group A for FVC, FEV1, FEV1/FVC were 0.18,0.37,14.48 and for Group B were 0.06,0.18,8.40 respectively. The p- value for FEV1 was 0.000 and for FEV1/FVC were 0.002. The mean scores for Group A for Axillary level, nipple level, xiphisternal level were 1.01, 1.10, 1.20 and for Group B were 0.88,1.06, 1.17 respectively. The p-value for Axillary level was 0.042. The present study concluded that there is statistically improvement on pulmonary function and chest expansion after immediate application of intercostal stretch and pursed lip breathing along with thoracic expansion exercise. But after immediate application of intercostal stretch along with thoracic expansion exercise there is more improvement on pulmonary function and chest expansion.

Keywords: Mild to moderate COPD, Pursed lip Breathing, Intercostal stretch, Chest Expansion, PFT.

INTRODUCTION

Chronic obstructive pulmonary disease is a widespread, preventable, and treatable condition defined by recurrent respiratory symptoms and persistent air-flow limitation caused by abnormalities in the airways and alveoli, which are usually induced by extensive exposure to noxious particles and gases." [1] "According to World Health Organization report, tobacco smoking contributed to more than 5 million fatalities.[2] The Global Initiative for Chronic Obstructive Lung Disease standards were created to provide healthcare workers with the best suggestions for diagnosing and managing COPD patients.[3] In COPD patients who have barrel-shaped chest, physical changes such as chest tightness occur.[4] Healthcare practitioners frequently utilize the cloth tape measurement approach to evaluate chest expansion.[5] It was used to assess the excursion of the chest wall at upper, middle, and lower lobes.[5] Breathing exercises have been an important part of a comprehensive pulmonary rehab program for individuals with COPD.[6] The purse-lip breathing technique allows users to control their oxygenation and ventilation.[7] The forces that occur during exhalation cause the cartilage-free airways to draw inward and toward the lumen, blocking airflow by raising airway resistance, which may result in carbon dioxide entrapment.[7] In (PNF), the muscle is passively stretched and alternately contracted.[1] This method expands the length of a muscle's nerve receptors.[1] So, the aim of the study is to compare the immediate effect of intercostal stretch along with thoracic expansion exercise and pursed lip breathing along with thoracic expansion exercise on pulmonary function and thoracic expansion on mild-moderate COPD subjects.

MATERIALS AND METHODS

A comparative study was conducted on mild to moderate COPD subjects at Parul Sevashram Hospital, Vadodara, Gujrat. Following an initial screening subjects were selected Both males and females of age is between 40 to 60. [1] Patient with mild, moderate airway obstruction based on gold criteria: gold 1-(mild: fev1 /fvc < 0.70, FEV1 > 80% of predicted) gold 2 -(moderate: FEV1 /FVC < 0.70, 50% < FEV1 < 80% of predicted). [1] Medically diagnosed COPD patient. [8] Willing to participate. [8] smokers or ex-smokers of more than 10 pack-years, and symptoms suggestive of COPD. [9] Exclusion criteria were Hemodynamically unstable subjects. [10] Patients with severe orthopedic problems related to spine, fracture of rib, sternum fracture, neurological deficits, affecting the respiratory muscles, unstable cardiac condition, recent myocardial infarction, intercostal muscles strain. [1] Previous lung – volume reduction surgery, lung transplantation or pneumonectomy.[1] Patient is having history of core pulmonale.[1] Ethical approval was taken by Parul University institutional ethics committee for Human Research (PUIECHR/PIMSR/00/081734/4502). The trial was registered prospectively at the clinical trials registry of India (CTRI/2023/04/051427).





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Outcome measures

1. **Pulmonary function (FEV1, FVC, FEV1/FVC):** “The patient was comfortably seated in front of a PFT machine. The mouthpiece was placed comfortably between the two lips, preventing excess air escaping from the mouth. The patient was then instructed to take a deep breath and exhale as much as possible for several seconds through a mouthpiece. It is not permitted to breathe through the nose. 2 to 3 repetitions were taken. The study included the following parameters: FEV1, FVC, and FEV1/FVC.”
2. **Chest expansion (tape method):** “Subjects were seated on stool, arms crossed behind their backs, heads turned to one side. A cloth tape was used to measure chest expansion at three different rib cage levels. The anatomical marks for thoracic expansion are the axillary level, nipple level, and xiphisternum level. The advantage of selecting these locations is that they represent the elasticity of different lobes. The subjects were instructed to exhale through their mouth, inhale slowly through their nose, and press their chest against the tape to measure the expansion of their lungs. The participants were instructed to exhale through their mouths. The cross-hand technique was used to take measurements at three different levels. Measurements were taken into centimeters (CM).”

Procedure

- Based on inclusion and exclusion criteria, subjects were recruited from the Parul Sevashram hospital in Vadodara. The study was carried out by informing the subjects about the study and obtaining their informed and written consent. The subjects' privacy and confidentiality were respected.
- The study sample included subjects with mild to moderate COPD. The subjects were interviewed, and the clinical histories of the participants were known.
- Prior to starting the intervention, outcome measures in the form of a pulmonary function test and chest expansion were evaluated. The treatment time was 45 minutes.
- After the intervention, i.e., at the end of 45 minutes, outcome measures were Re-evaluated, and a comparison of pre- and post-data were obtained.
- Statistical analysis was done and results were calculated.

Intervention

Subjects will be divided in 2 groups by randomization (chit method).

Group A: inter costal stretch

“patients were in a supine lying position.[1] The Therapist stand behind the patient.[1] First therapist should palpate the suprasternal notch then go downward about 5 cm to palpate the angle of louis.[1] Then trace the finger laterally to palate the 2nd rib and intercostal stretch was given bilaterally at 2nd and 3rd rib with the help of index finger and middle finger.[1] The direction of stretch was downward towards the next rib in midaxillary line.[1] The stretch was maintained as he/she continues to breathe.[1] The stretch was applied at the end of the exhalation for 10 breaths with 1 minute rest and for 10 repetitions. Total treatment duration was 45 minutes.” [1]

Group A: inter costal stretch along with thoracic expansion exercise

Intercostal stretch (10 Breaths With 1 Min Rest For 10 Repetition) [1] Thoracic expansion exercise (breathing with mainly expiration: - 15 minutes of breathing exercise after 2 minute of respiration subjects rested for 1 minute) [11]

Group B: “Pursed lip breathing exercise

Patients were assigned a comfortable seating position.[12] Patients were instructed to inhale slowly through the nose and hold it for 3 to 4 seconds before exhaling gradually and slowly through the mouth by pursing the lips together so that if a flame is held in front of them, the flame bends but does not blow off.[12]Expiration should last approximately twice as long as inspiration.[13] Total 10 Repetition With 5 Min Rest For 3 Set were done.”[12]

Group B: pursed lip breathing along with thoracic expansion exercise

Pursed lip breathing (10 Repetition With 5 Min Rest For 3 Set) [12] Thoracic expansion exercise (breathing with mainly expiration: - 15 minutes of breathing exercise after 2 minute of respiration subjects rested for 1 minute) [11]



**Dhruvika D. Rathod and Didhiti Desai****Thoracic expansion exercise**

“The patient was sitting comfortably in a chair.[11] The therapist stands in front of the patient and instructs him or her to inhale slowly and deeply through the mouth, followed by a prolonged expiration through the mouth.[11] Expiration is the primary mode of breathing (15 minutes of breathing exercise after 2 minute of respiration subjects rested for 1 minute).” [11]

STATISTICAL ANALYSIS

Non-parametric tests were used to analyse the results. IBM SPSS version 27 software was used for analysis. Normality was checked by using Shapiro Wilk Test. Mann-Whitney U test was used for between group analysis and for within group pre and post analysis Wilcoxon Signed Rank test was used. The alpha level of 0.05 was kept for analysis of data. Micro soft word and excel version 2010 were used to create group and tables.

RESULTS AND DISCUSSION**Result****WITHIN GROUP ANALYSIS OF GROUP A**

Table 1.1 shows pre and post intervention mean±SD variance of PFT for Group A. Wilcoxon Signed Ranks Test was used for analysis of data. The pre- intervention mean±SD value for FVC was 1.956±0.746, post intervention mean±SD value for FVC was 2.140±0.899, pre- intervention mean±SD value for FEV1 was 1.233±0.473, post intervention mean±SD value for FEV1 was Table 1.2 shows pre and post intervention mean±SD variance of chest expansion for Group A. Wilcoxon Signed Ranks Test was used for analysis of data. The pre- intervention mean±SD value for axillary level was 1.216±0.363, post intervention mean±SD value for axillary level was 2.233±0.409, pre- intervention mean±SD value for nipple level was 1.683±0.444, post intervention mean±SD value for nipple level was 2.783±0.386, pre- intervention mean±SD value for xiphi-sternal level was 2.066±0.468, post intervention mean±SD value for xiphi-sternal level was 3.266±0.449. p- value for chest expansion at axillary, nipple, xiphisternal level was found out to be 0.000 with $p < 0.005$ which is considered to be significant. Table 1.3 shows pre and post intervention mean±SD variance of PFT for Group B. Wilcoxon Signed Ranks Test was used for analysis of data. The pre- intervention mean±SD value for FVC was 1.771±0.589, post intervention mean±SD value for FVC was 1.834±0.653, pre- intervention mean±SD value for FEV1 was 1.038±0.411, post intervention mean±SD value for FEV1 was 1.225±0.562, pre- intervention mean±SD value for FEV1/FVC was 57.992±10.843, post intervention mean±SD value for FEV1/FVC was 66.399±14.870. p-value for FVC, FEV1, FEV1/FVC was found out to be 0.000 with $p < 0.05$ which is considered to be significant. Table 1.4 shows pre and post intervention mean±SD variance of chest expansion for Group A. Wilcoxon Signed Ranks Test was used for analysis of data. The pre- intervention mean±SD value for axillary level was 1.2333±0.40965, post intervention mean±SD value for axillary level was 2.116±0.536, pre- intervention mean±SD value for nipple level was 1.483±0.463, post intervention mean±SD value for nipple level was 2.550±0.461, pre- intervention mean±SD value for xiphi-sternal level was 1.850±0.511, post intervention mean±SD value for xiphi-sternal level was 3.026±0.532. p- value for chest expansion at axillary, nipple, xiphisternal level was found out to be 0.000 with $p < 0.005$ which is considered to be significant.

BETWEEN GROUP ANALYSIS OF GROUP-A AND GROUP- B FOR PFT

Table 1.5 shows the pre and post intervention mean variance of Fvc, FEV1, FEV1/FVC for Group A and B. Mann-Whitney Test was used for analysis of data, pre and post-test mean ±SD value for group A was 0.18±0.25, 0.37±0.16, 14.48±7.33 and for group B was 0.06±0.24, 0.187±0.203, 8.40±6.12 p-value for FEV1 was found to be 0.000 with $p < 0.05$. post intervention both the groups showed significant improvement but FEV1 was more improved in Group A compared than Group B.



**Dhruvika D. Rathod and Didhiti Desai****BETWEEN GROUP ANALYSIS OF GROUP-A AND GROUP- B FOR CHEST EXPANSION**

Table 1.6 shows the pre and post intervention mean variance of Axillary, Nipple, Xiphisternal level for Group A and B. Mann-Whitney Test was used for analysis of data, pre and post-test mean \pm SD value for group A was 1.01 ± 0.35 , 1.10 ± 0.35 , 1.20 ± 0.48 and for group B was 0.88 ± 0.25 , 1.06 ± 0.50 , 1.17 ± 0.32 p-value for FEV1 was found to be 0.000 with $p < 0.05$. post intervention both the groups showed significant improvement but FEV1 was more improved in Group A compared than Group B. In present study, within group analysis showed that there was statistically significant improvement in all Parameters of PFT (FVC, FEV1, FEV1/FVC) with ($P < 0.05$) in Group A and Group B. The findings of present study showed that after implementation of both the treatments There was a statistically significant change in dynamic ventilatory measures in FEV1 ($P < 0.000$), FEV1/FVC% ($P < 0.002$) in both the Groups. Clinically there was changes in FVC, Nevertheless, no statistically significant difference was seen in FVC. ($P > 0.05$).

DISCUSSIONS

The current study aimed to compare the immediate effect of intercostal stretch along with thoracic expansion exercise and pursed lip breathing along with thoracic expansion exercise on pulmonary function and thoracic expansion on mild to moderate COPD subjects. The improvement in pulmonary function and chest expansion can be explained by **Dangi Ashwini ET al.** "Intercostal stretch may improve chest wall elevation and thus increase expansion to improve intra-thoracic lung volume.[10] This may contribute to an increase in ventilatory capacity, such as tidal volume, minute ventilation, and oxygen status, improving chest expansion, hyperinflation, and air trapping, and thus reducing breathlessness." [10] "The changes in ventilatory parameters could be attributed while giving passive stretch which activates stretch receptors in the chest wall which are linked to the medulla via efferent nerve cells.[10] Intercostal muscles aid in the upward and outward movement of the ribs, resulting in an increase in the anterior posterior diameter of the thoracic cavity.[10] It is beneficial for both inspiration and forced expiration." [10] The findings of our study, which were substantiated by **Mohan V, Bdlisyah, et al.** (2012), examined the "effect of intercostal stretch on pulmonary function parameters.[14] The experimental group in this study received intercostal stretching with breathing control, while the control group received breathing control exercise.[14] The study's findings revealed that FEV1/FVC% and FEV1 in the experimental group significantly improved with $P = 0.017$ ($P < 0.05$). However, there were no significant differences in FEV1 or FVC." [14] When the respiratory muscles, which are crucial to pulmonary function, are treated similarly to skeletal muscles, they not only improve muscle strength and endurance, but they can also enhance maximum inspiratory pressure, maximum expiratory pressure, and pulmonary function.[11] Our study were supported by Seong-Dae Woo et al. (2016), "To measure and verify any changes in chest and pulmonary functions when breathing with primarily inspiration or expiration was performed, and to propose a suitable intervention and exercise method for patients with lung disease." [11]

"A comparison of the BMIG and BMEG results before and after exercise revealed that the BMIG had significant differences in CSI, CEV, FVC.[11] breathing primarily with inspiration contracted not only the diaphragm, which is an inspiratory muscle, but also the inspiratory accessory muscles such as the sternocleidomastoid, scalenus, trapezius, pectoralis major, pectoralis minor, and serratus anterior, resulting in chest expansion.[11] Because breathing with primarily expiration contracts the rectus abdominis, transversus abdominis, obliques, and internal intercostals.[11] Prior to the experiment, there were no significant differences between the groups; however, changes in the measured variables after the experiment revealed that the BMEG showed significantly different increases in CSE, CEV, FEV1/FVC. Because breathing primarily with expiration activated abdominal muscles that are not used during normal breathing." [8] Our study was supported by **Sharp, J.T.; Cluzel, P.; et al.** (2020) reported that "improvement in chest expansion was greater at the level of the axilla than the xiphisternum. Inspiratory muscle stretching has no effect on lung structure; thus, the increase in chest expansion could be due to improved chest wall mobility. Increased chest wall mobility is frequently asynchronous with abdominal motion, either due to diaphragm weakness or increased excursion." [15] "Pursed lip breathing enhances oxygenation, muscle relaxation thus it has a significant impact on increasing lung capacity and respiratory muscle strength.[16] The airway's forces from the exhalation flow are resisted by the positive pressure that is produced.[16] Therefore, pursed-lip breathing aids in



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breathing by expanding the airways during exhalation and promoting the excretion of volatile acids in the form of carbon dioxide, which prevents or relieves hypercapnia.” [16] So, if any future study intended to analyse the immediate effect of intercostal stretch along with thoracic expansion exercise on pulmonary functions (FVC, FEV1, FEV1/FVC%) then it can be implemented. Chest expansion at (axillary, nipple, xiphisternal levels) can be used as a part of outcome assessment to predict the expansion of lungs in COPD subjects.

CONCLUSION

The present study concluded that there is statistically improvement on pulmonary function and chest expansion after immediate application of intercostal stretch and pursed lip breathing along with thoracic expansion exercise. But after immediate application of intercostal stretch along with thoracic expansion exercise there is more improvement on pulmonary function and chest expansion.

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Table 1 shows about distribution of age of both Group A and Group B.

AGE	GROUP A	GROUP B	TOTAL
40-45	4	7	11
46-50	6	6	12
51-55	7	4	11
56-60	13	13	26
Total	30	30	60

Table: 2 - pre-post comparison of pft value of group A

GROUP A	MEAN	±SD	Z VALUE	P VALUE	TEST
PRE FVC	1.95	0.74	3.21	0.000	Wilcoxon Signed Ranks Test
POST FVC	2.14	0.89			
PRE FEV1	1.23	0.47	4.79	0.000	
POST FEV1	1.60	0.57			
PRE FEV1/FVC	62.89	0.89	4.79	0.000	
POST FEV1/FVC	77.38	11.22			

Table: 3– pre-post comparison of chest expansion value of group A

GROUP A	MEAN	±SD	Z VALUE	P VALUE	TEST
PRE CE AL	1.21	0.36	5.20	0.000	Wilcoxon Signed Ranks Test
POST CE AL	2.23	0.40			
PRE CE NL	1.68	0.44	4.90	0.000	
POST CE NL	2.78	0.38			
PRE CE-XL	2.06	0.46	4.74	0.000	
POST CE XL	3.26	0.44			

Table: 4- pre-post comparison of pft value of group b

GROUP A	MEAN	±SD	Z VALUE	P VALUE	TEST
PRE CE AL	1.23	0.40	5.00	0.000	Wilcoxon Signed Ranks Test
POST CE AL	2.11	0.53			
PRE CE NL	1.48	0.46	4.86	0.000	
POST CE NL	2.55	0.46			
PRE CE-XL	1.85	0.51	4.89	0.000	
POST CE XL	3.02	0.53			





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Table: 5- inter-group comparison of fvc, fev1, fev1/fvc

PFT	GROUP	MEAN	±SD	Z-VALUE	P-VALUE	TEST
FVC	A	0.18	0.25	1.43	0.153	Mann-Whitney Test
	B	0.06	0.24			
FEV1	A	0.37	0.16	3.55	0.000	Mann-Whitney Test
	B	0.18	0.20			
FEV1/FVC	A	14.48	7.33	3.06	0.002	Mann-Whitney Test
	B	8.40	6.12			

Table: 6- inter-group comparison of axillary, nipple, xiphisternal level

CHEST EXPANSION LEVEL	GROUP	MEAN	±SD	Z-VALUE	P-VALUE	TEST
AXILLARY LEVEL	A	1.01	0.24	2.03	0.042	Mann-Whitney Test
	B	0.88	0.25			
NIPPLE LEVEL	A	1.10	0.35	0.79	0.428	Mann-Whitney Test
	B	1.06	0.50			
XIPHIISTERNAL LEVEL	A	1.20	0.48	0.32	0.744	Mann-Whitney Test
	B	1.17	0.32			





Odd-Prime Graceful Labelling and Odd-Even Prime Graceful Labelling

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ABSTRACT

Prime Labeling, Graceful Labeling, Prime Graceful Labeling, Odd-Graceful Labeling and Odd-Even Graceful Labeling were investigated in this research. The new labeling techniques Odd-Prime Graceful Labeling and Odd-Even Prime Graceful Labeling are proposed along with the subsequent results. The result concerning Odd-Prime Graceful Labeling of Star and Bistar graph and Odd-Even Prime Graceful Labeling of Path Graph, Star Graph and Pan Graph were presented. Furthermore, the efficacy of the new Labeling Techniques are evaluated using the compatible examples.

Keywords: Prime Graceful Labeling, Odd-Graceful Labeling, Odd-Prime Graceful Labeling, Odd-Even Graceful Labeling, Odd-Even Prime Graceful Labeling .

INTRODUCTION

This paper focused on finite simple undirected graphs. The set of vertices $V(G)$, set of elements $E(G)$ and its incidence relation make up the graph G . To obtain a comprehensive list of terms used in graph theory, the following book [1] is considered. Graph Labeling was first developed by Rosa [6] who also provided several graph labeling methods and specifically came up with the phrase β -labeling and it was renamed by Solomon.W.Golomb [4] as graceful labeling. Later, Roger Entringer introduced prime labeling where Tout et.all [10] analyzed a few different kinds of graphs to find the ones that allows for prime labelling. Gnanajothi [3] defined odd-graceful graphs and identified some of the graphs that allows odd-graceful labelling. Furthermore, Sridevi et.all [9] instigated odd-even graceful graphs and found some graphs which admits odd-even graceful labeling. The survey of graph labelling conducted by Gallian J.A[2] is also referred. In 2018 Selvarajan. T.M, Subramoniam. R [8] combined prime and





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graceful labelling and introduced a new labeling technique Prime Graceful Labeling and demonstrated the existence of prime graceful labelling in some graphs. Sayan Panma and Penying Rochanakul [7] also generated prime-graceful graphs and introduced prime-graceful number. In addition to applying the prime graceful labeling to certain graphs, Nandhini. S.P. and Pooja Lakshmi. B [5] generalized the cardinality of the edges for the triangular snake graph. In this paper, the new labeling technique odd-prime graceful labeling and odd-even prime graceful labeling are introduced and analyzed for some connected graphs. Star, Bistar, Path and Pan graphs have been taken into consideration.

PRELIMINARIES

Definition: 2.1

For a Graph $G = (V, E)$ process of assigning labels to the vertices or the edges of a graph is known as **labeling**. Labels are often represented by integers.

Definition: 2.2

For a graph $G = (V, E)$ with p vertices and q edges, if the mapping $\omega: V(G) \rightarrow \{1, 2, 3, \dots, p\}$ are used to label the vertices of a graph with vertex set V in such a way that the labels given to distinct vertices x and y are relatively prime, (i.e) $\gcd(\omega(x), \omega(y)) = 1$ then the graph is said to have a **prime labeling**.

Definition: 2.3

A graph G with p vertices and q edges is referred to have **graceful labeling** if the map depicts a one to one function ω from the vertices of G to $\{0, 1, 2, \dots, p\}$ and the map reflect the induced one-to-one function ω^* from the edges of G to $\{1, 2, \dots, p\}$ defined by $\omega^*((v_i), (v_j)) = |\omega(v_i) - \omega(v_j)|$. So that the resulting edge labels are distinct.

Definition: 2.4

A graph G with p vertices and q edges is referred to as having **prime graceful labeling** if the map depicts a one to one function ω from the vertices of G to $\{1, 2, \dots, k\}$. In this instance, the value $k = \min\{p, q\}$ such that the $\gcd(\omega(v_i), \omega(v_j)) = 1$ and the map reflect the induced one-to-one function ω^* from the edges of G to $\{1, 2, \dots, k-1\}$ defined by $\omega^*((v_i), (v_j)) = |\omega(v_i) - \omega(v_j)|$. Thus, edge labels are different.

Definition: 2.5

A graph G with p vertices and q edges admits **odd-graceful labeling** if the injective function ω from $V(G)$ to $\{0, 1, 2, \dots, 2q-1\}$ and the map reflect the induced function ω^* from the $E(G)$ to $\{1, 3, 5, \dots, 2q-1\}$ defined by $\omega^*((v_i), (v_j)) = |\omega(v_i) - \omega(v_j)|$.

Definition: 2.6

A graph G with p vertices and q edges admits **odd-prime graceful labeling** if the injective function ω from the $V(G)$ to $\{1, 2, \dots, 2q\}$ in such a way that $\gcd(\omega(v_i), \omega(v_j)) = 1$ where $v_i, v_j \in E(G)$ and the map reflect the induced function ω^* from $E(G)$ to $\{1, 3, 5, \dots, 2q-1\}$ defined by $\omega^*((v_i), (v_j)) = |\omega(v_i) - \omega(v_j)|$. Odd-Prime Graceful graph refers to the graph that allows odd-prime graceful labeling.

Definition: 2.7

A graph G with p vertices and q edges admits **odd-even graceful labeling** if the injective function ω from $V(G)$ to $\{1, 3, 5, \dots, 2q+1\}$ and the map reflect the induced function ω^* from the $E(G)$ to $\{2, 4, 6, \dots, 2q\}$ defined by $\omega^*((v_i), (v_j)) = |\omega(v_i) - \omega(v_j)|$.

Definition: 2.8

A graph G with p vertices and q edges admits **odd-even prime graceful labeling** if the injective function ω from the $V(G)$ to $\{1, 3, \dots, 2q+1\}$ in such a way that $\gcd(\omega(v_i), \omega(v_j)) = 1$ $v_i, v_j \in E(G)$ and the map reflect the induced





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function ω^* from $E(G)$ to $\{2,4,6,\dots,2q\}$ defined by $\omega^*((v_i), (v_j)) = |\omega(v_i) - \omega(v_j)|$. Odd-Even Prime Graceful graph refers to the graph that allows odd-even prime graceful labeling.

Odd-Prime Graceful Labeling of Star and Bistar graph

Theorem: 3.1

For any positive integers n , the star graph $K_{1,n}$ admits odd-prime graceful labeling.

Proof

The Star graph of order n is taken into consideration. Let $\{v_1, v_2, v_3, \dots, v_n\}$ be the vertices of the star graph. $V(K_{1,n}) = \{v_i : 1 \leq i \leq n+1\}$. Then, $K_{1,n}$ is a graph with $|V(G)| = n+1$ vertices and $|E(G)| = n$ edges. Define a labeling ω for vertex set as, $\omega : V(G) \rightarrow \{1, 2, 3, \dots, 2q\}$ where q is the total number of edges. Label the vertex of degree n with 1 and the n -pendant vertices are designated as $2, 4, 6, \dots, 2q$. For $1 \leq i \leq n$, $\omega(v_i) = 2i$. The adjacent vertices can be demonstrated as relatively prime. $GCD(\omega(v_i), \omega(v_j)) = GCD(\omega(v_i), 1) = GCD(2i, 1) = 1$

Since among these two numbers one is odd and other is even.

Define a labeling ω^* for edge set as, $\omega^* : E(G) \rightarrow \{1, 3, 5, \dots, 2q-1\}$ where q is the total number of edges. For $1 \leq i \leq n$, $\omega^*(E(G)) = 2i-1$. It is determined by

$\omega^*((v_i), (v_j)) = |\omega(v_i) - \omega(v_j)| = |\omega(v_i) - \omega(v_1)| = |2i-1| = 1, 3, 5, \dots, 2q-1$. Consequently the edge labels are distinct. Thus, ω is odd-prime graceful labeling.

Therefore, $K_{1,n}$ is an odd-prime graceful graph.

Theorem: 3.2

For any positive integers n , the bistar graph $B_{n,n}$ admits odd-prime graceful labeling.

Proof

The Bistar graph of order n is taken into consideration. Let $\{u_1, u_2, u_3, \dots, u_{n+1}, v_1, v_2, v_3, \dots, v_{n+1}\}$ be the vertices of the bistar graph. $V(B_{n,n}) = \{u_i : 1 \leq i \leq n+1\} \cup \{v_i : 1 \leq i \leq n+1\}$

Then, $B_{n,n}$ is a graph with $|V(G)| = 2n+2$ vertices and $|E(G)| = 2n+1$ edges.

Define a labeling ω for vertex set as, $\omega : V(G) \rightarrow \{1, 2, 3, \dots, 2q\}$ where q is the total number of edges. Let u_1 and v_1 be the apex vertices of the bistar graph and label the vertex u_1 as 1 and v_1 as 2. Since the adjacent vertices u_1 and v_1 are 1 and 2, $GCD(\omega(u_1), \omega(v_1)) = 1$.

The pendant vertices of u_i are designated as $6, 8, 10, \dots, 2q$

For $2 \leq i \leq n$, $\omega(u_i) = 2(i+n)$. The adjacent vertices can be demonstrated as relatively prime.

$GCD(\omega(u_i), \omega(u_1)) = GCD(\omega(u_i), 1) = GCD(2(i+n), 1) = 1$

Since among these two numbers one is odd and other is even.

The pendant vertices of v_i are designated as $3, 5, 7, \dots, q$.

For $2 \leq i \leq n$, $\omega(v_i) = 2i+1$, The adjacent vertices can be demonstrated as relatively prime.

$GCD(\omega(v_i), \omega(v_1)) = GCD(\omega(v_i), 2) = GCD(2i+1, 2) = 1$

Since among these two numbers one is odd and other is even.

Define a labeling ω^* for edge set as, $\omega^* : E(G) \rightarrow \{1, 3, 5, \dots, 2q-1\}$ where q is the total number of edges. For $1 \leq i \leq n$, $\omega^*(E(G)) = 2i-1$.

It is determined by $\omega^*((u_1), (v_1)) = |\omega(u_1) - \omega(v_1)| = |1-2| = 1$

$\omega^*((u_i), (u_1)) = |\omega(u_i) - \omega(u_1)| = |2(i+n)-1|$

$\omega^*((v_i), (v_1)) = |\omega(v_i) - \omega(v_1)| = |2i+1-2| = |2i-1|$

It forms the consecutive odd integers. Consequently the edge labels are distinct.

Thus, ω is odd-prime graceful labeling. Therefore, $B_{n,n}$ is an odd-prime graceful graph.





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Odd-Even Prime Graceful Labeling of Path, Pan and Star graph

Theorem: 4.1

For any positive integers n , the path graph P_n admits odd-even prime graceful labeling.

Proof

The Path graph of order n is taken into consideration. Let $\{v_1, v_2, v_3, \dots, v_n\}$ be the vertices of the path graph. $V(P_n) = \{v_i : 1 \leq i \leq n\}$. Then, P_n is a graph with $|V(G)| = n$ vertices and $|E(G)| = n - 1$ edges. Define a labeling ω for vertex set as, $\omega : V(G) \rightarrow \{1, 2, 3, \dots, 2q + 1\}$ where q is the total number of edges.

If n is odd, label the vertex $\left(\frac{n+3}{2}\right)^{th}$ with 1. If n is even, label the vertex $\left(\frac{n}{2} + 1\right)^{th}$ with 1.

The adjacent vertices of vertex label 1 is designated as $3, 5, 7, \dots, 2q + 1$

For $1 \leq i \leq n$, $\omega(v_i) = 2i + 1$. The adjacent vertices can be demonstrated as relatively prime.

$$\text{GCD}(\omega(v_i), \omega(v_{i+1})) = \text{GCD}(2i + 1, (2(i + 1) + 1)) = \text{GCD}(2i + 1, (2i + 1) + 2) = 1$$

Since these two numbers are consecutive odd integers.

Define a labeling ω^* for edge set as, $\omega^* : E(G) \rightarrow \{2, 4, 6, \dots, 2q\}$ where q is the total number of edges. For $1 \leq i \leq n$, $\omega^*(E(G)) = 2i$. It is determined by

$$\omega^*((v_i), (v_j)) = |\omega(v_i) - \omega(v_{i+1})| = |2i + 1 - (2(i + 1) + 1)| = 2, 4, 6, \dots, 2q$$

As the difference of two odd numbers is even. Consequently the edge labels are distinct.

Thus, ω is odd-even prime graceful labeling. Therefore, P_n is a odd-even prime graceful graph.

Theorem: 4.2

For any positive integers $n \geq 3$, the pan graph admits odd-even prime graceful labeling.

Proof:

The Pan graph of order $n + 1$ is taken into consideration. Let $\{v_1, v_2, v_3, \dots, v_{n+1}\}$ be the vertices of the pan graph. $V(G) = \{v_i : 1 \leq i \leq n + 1\}$. Then, pan graph consist of $|V(G)| = n + 1$ vertices and $|E(G)| = n + 1$ edges. Define a labeling ω for vertex set as, $\omega : V(G) \rightarrow \{1, 2, 3, \dots, 2q + 1\}$ where q is the total number of edges. The vertex with the highest degree in the pan graph designated as 1. The adjacent vertices of vertex label 1 is designated as $3, 5, 7, \dots, 2q + 1$

For $1 \leq i \leq n$, $\omega(v_i) = 2i + 1$. The adjacent vertices can be demonstrated as relatively prime.

$$\text{GCD}(\omega(v_i), \omega(v_{i+1})) = \text{GCD}(2i + 1, (2(i + 1) + 1)) = \text{GCD}(2i + 1, (2i + 1) + 2) = 1$$

As these given two numbers are consecutive odd integers that follows one another.

Define a labeling ω^* for edge set as, $\omega^* : E(G) \rightarrow \{2, 4, 6, \dots, 2q\}$ where q is the total number of edges. For $1 \leq i \leq n$, $\omega^*(E(G)) = 2i$. It is determined by

$$\omega^*((v_i), (v_j)) = |\omega(v_i) - \omega(v_{i+1})| = |2i + 1 - (2(i + 1) + 1)| = 2, 4, 6, \dots, 2q$$

Since there is an even difference between two odd numbers. Consequently the edge labels are distinct. Thus, ω is odd-even prime graceful labeling.

Therefore, n -pan graph is a odd-even prime graceful graph.

Theorem: 4.3

For any positive integers n , the star graph $K_{1,n}$ admits odd-even prime graceful labeling.

Proof

The star graph of order n is taken into consideration. Let $\{v_1, v_2, v_3, \dots, v_n\}$ be the vertices of the star graph. $V(K_{1,n}) = \{v_i : 1 \leq i \leq n\}$. Then, $K_{1,n}$ is a graph with $|V(G)| = n + 1$ vertices and $|E(G)| = n$ edges. Define a labeling ω for vertex set as, $\omega : V(G) \rightarrow \{1, 2, 3, \dots, 2q + 1\}$ where q is the total number of edges.

Label the vertex of degree n with 1. The n -pendant vertices are designated as $3, 5, 7, \dots, 2q + 1$.

For $1 \leq i \leq n$, $\omega(v_i) = 2i + 1$. The adjacent vertices can be demonstrated as relatively prime.

$$\text{GCD}(\omega(v_i), \omega(v_{i+1})) = \text{GCD}(2i + 1, (2(i + 1) + 1)) = \text{GCD}(2i + 1, (2i + 1) + 2) = 1$$

As these given two numbers are consecutive odd integers that follows one another.





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Define a labeling ω^* for edge set as, $\omega^* : E(G) \rightarrow \{2, 4, 6, \dots, 2q\}$ where q is the total number of edges. For $1 \leq i \leq n$, $\omega^*(E(G)) = 2i$. It is determined by

$$\omega^*((v_i), (v_j)) = |\omega(v_i) - \omega(v_{i+1})| = |2i + 1 - (2(i + 1) + 1)| = 2, 4, 6, \dots, 2q$$

Since there is an even difference between two odd numbers.

Consequently the edge labels are distinct.

Thus, ω is odd-even prime graceful labeling.

Therefore, $K_{1,n}$ is a odd-even prime graceful graph.

CONCLUSION

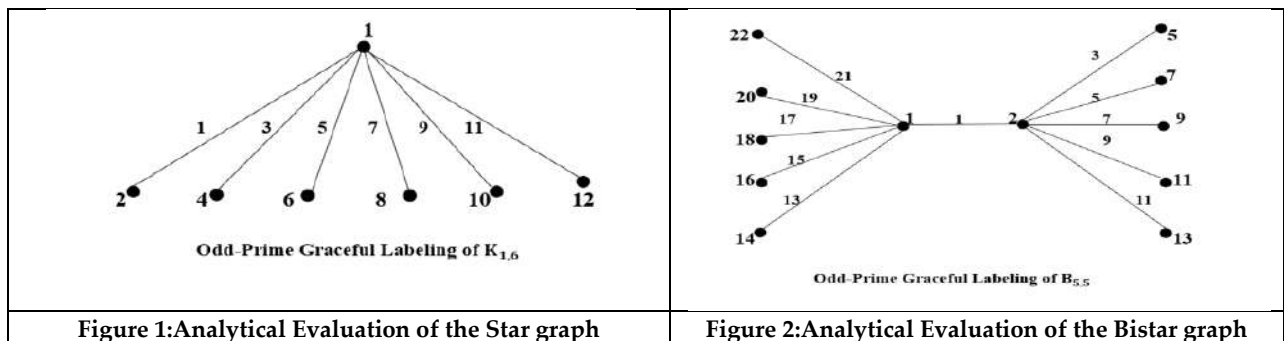
The most advantageous area of graph theory is graph labeling which has numerous applications. It is demonstrated that odd-prime graceful labeling is admissible for star graph, bistar graph and odd-even prime graceful labeling is admissible for the path graph, pan graph, and star graph. Furthermore, the newly developed labeling techniques are illustrated with examples. We would also investigate thoroughly other graphs which permits odd-prime graceful labeling and odd-even prime graceful labeling.

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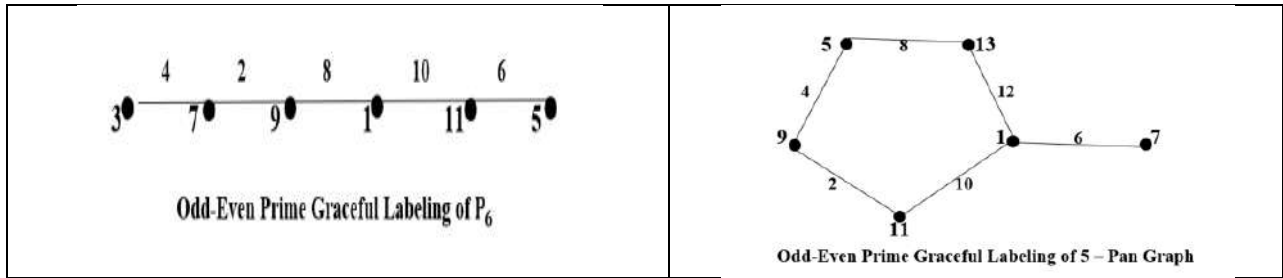


Figure 3: Analytical Evaluation of the Path graph

Figure 4: Analytical Evaluation of the Pan graph

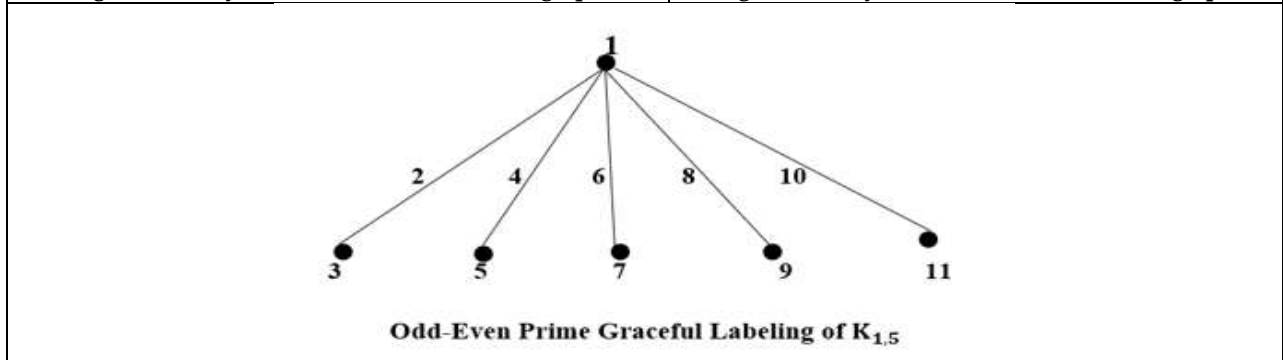


Figure 5: Analytical Evaluation of the Star graph





Effectiveness of Pre and Post Test Model of Learning in Dental School

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ABSTRACT

Conventional lecture is one of the most widely practiced method in teaching – learning. Due to vast syllabus and restricted time allocated per module, makes it difficult to receive feedback and provide necessary corrective actions. Objective was to evaluate knowledge of attendees of lecture using Pre and Post questionnaire model. Faculty, PG students and Interns, after acquiring their consent for participation were provided with pre-test questionnaire and the questionnaire were given as post test to evaluate the effectiveness of teaching as well as receptive power of attendees by comparing pre and post valuation. There was significant improvement in attendees' knowledge after the lecture. Also, there was improvement in median scores from pre to post lecture by 5. Out of 43 participants, 40 got positive ranks indicating improvement in knowledge in post test. Such pre and post test model will help evaluate effectiveness of teachers teaching skills and amount of knowledge gained by attendees.

Keywords: students, lecture, knowledge, scores.



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INTRODUCTION

Didactic lectures been widely used as teaching – learning method. A pre – post evaluation of participants help evaluate the knowledge gained. Some of the active learning strategies help gain the grasp on three major domains of analysis, synthesis and evaluation. Dental education keep undergoing re-modeling phases based on vis-à-vis basis and in tandem with National Education Policy, 2020. NEP, 2020 mandates using of multiple knowledge dissemination tools and also help implement the evaluation strategies [1]. Dating back to 1899, Sir Osler emphasized the complexity of medical care and challenges for teachers to teach everything that student need to know.²And traditional methods of teaching and learning (T – L) methods are no longer sufficient enough. Current Gen Z generation dental students and dentists have grown – up in Social Medica Civilization and it is insufficient and unreasonable to teach them using methods deployed decades ago.

Research in healthcare is at its peak importance currently in both developed and developing countries, especially after Covid -19 outbreak. With increasing knowledge and expertise requirement; the study was intended to deliver a didactic lecture on the same topic which not only will be of interest but also will help in achieving at most concentration during the lecture. The current study was undertaken to evaluate the effectiveness of didactic lecture using Pre-Post test model among dental faculty, dental post-graduates and interns of dental institute irrespective of their demographics.

Need for the study

Didactic lecture was designed with pre and post-test method to assess the effectiveness. This sort of a test method was first of a kind in our institute and was believed to be increasing the receptive capacity along with improvement in thinking, understanding and attention of participants.

Aim and Objectives

This assessment method was employed on faculty, post graduates and interns to check the possibility of inculcating the Pre-Post test method for undergraduate training program in dentistry.

MATERIALS AND METHODS

This study was conducted in a dental institute in Western Maharashtra. Total of 180 participants were invited for didactic lecture through circulars well in prior, with an intent to gather their consent to be part of this exercise. None of the circulars mentioned anything related to test planned during lecture to avoid bias, if any. Total of 60 individuals turned up for the lecture comprising of faculties, post graduate students and interns. Out of which, 43 agreed to be part of the study with their written consent. Before commencement of study, Institutional Ethical Committee approval was obtained.

Before beginning of the lecture, written consent was obtained and pre-test copy was distributed to participants comprising of pre – formed 5 questions of objective nature. The lecture was delivered for about 40 minutes, following which post – test comprising of same questions were administered to participants. This was a pre – tested questionnaire for validity. Scoring was done by single subject expert for both pre and post test, other than the lecturer. Scoring was ranging from 0 to 15 for both pre and post test.

Statistical analysis

Collected data was compiled using Microsoft Excel and Wilcoxon Signed Rank Test was used to assess the statistical difference between paired scale data. P – value was considered significant at $P < 0.05$.





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RESULTS

A total of 43 participants were part of the study. among those, Pre – test showed 7 median whereas, Post – test showed median of 11. (Table 1) (Graph 1) This shows marked improvement in scores after lecture. However, to check the statistical significance between Pre and Post test, Wilcoxon Signed Rank Test was used, where statistical significant improvement was observed in Post – Test (Positive ranks>Negative ranks, $P<0.001$) (Table 2). Also, the total of 40 participants showed positive ranks indicating direct improvement post lecture; with only 2 participants showing negative ranks and 1 with tie between pre and post test.

DISCUSSION

A prospective study was conducted to assess the pre – test before lecture on the same topic selected improves the performance of the participants in immediate post – test. Majority of the participants felt that conducting pre – test was helpful in improving their attentiveness and understanding of the subject. The reason could be self-realization towards inability to answer pre-test to satisfactory level, which is in tandem with previously conducted similar study [3]. These discernments from participants regarding pre – test was confirmed with statistical significant post – test improvement in scores ($P<0.001$).⁴⁻⁵In post – test, the improvement in scores by median of 5 (Table 1). This type of self evaluation immediately by participants was encouraging and stimulating to study and concentrate more during didactic lectures. These pre and post test measurements are widely used for assessing the impact of interventions and are of great use in behavioural research.⁶ Thus, it is apt to say that, such pre and post test models will be helpful in achieving the learning objectives and help better disseminate the knowledge.

CONCLUSION

Conventional didactic lecture been there in practice for decades and will remain viable for foreseeable future. The application of this pre and post test model will be helpful in self – evaluation of students and also aid in formative assessment of teaching – learning methods. Although, the current study was conducted on very less number of participants though covering various strata of dentistry including, dental faculty with various years of experience in teaching, post graduate students of different stream and internship residents. For conclusive evidence, further study with diverse and more number of participants need to be conducted.

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Table 1: Mean, median and standard deviation for Pre test and Post test among participants.

	n	Mean	Median	Standard deviation
Pre – Test	43	7.12	7	3.27
Post – Test	43	11.33	11	2.16



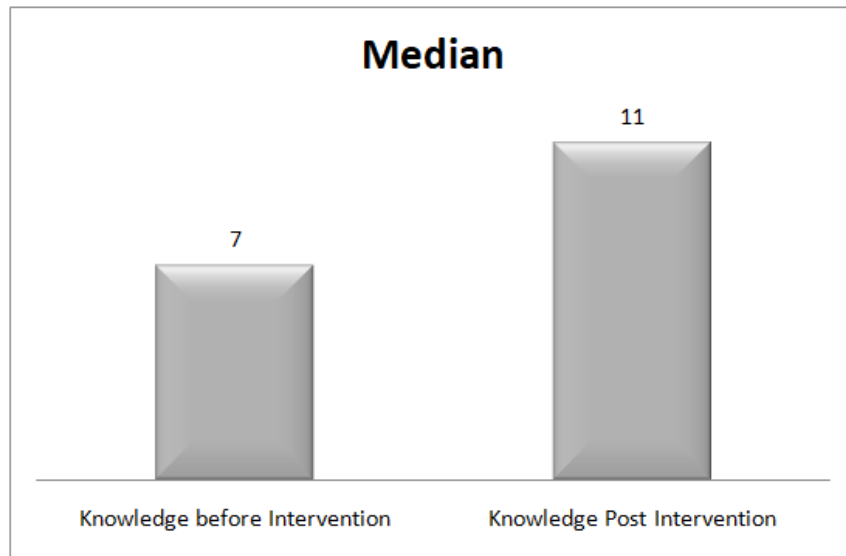


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Table 2: Comparison of Pre and Post test scores using Wilcoxon Signed Rank Test

		N	Mean Rank	Sum of Ranks	Z	P value
Knowledge post lecture - Knowledge prelecture	Negative Ranks	2	3.5	7	-5.57	0.001*
	Positive Ranks	40	22.4	896		
	Ties	1				
Negative Ranks: Knowledge post lecture < Knowledge before lecture						
Positive Ranks: Knowledge post lecture > Knowledge before lecture						
Ties: Knowledge post lecture = Knowledge before lecture						

*Statistical significance set at 0.05; N: Number of samples



Graph 1: Median for Pre and Post test among participants





Tele – Rehabilitation in the management of post modified radical mastectomy patients

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ABSTRACT

Breast Cancer is a leading cause of women death in India and it is measured to have one out of every 28 Indian women are under risk of developing breast cancer. And as a part of treatment, Modified Radical Mastectomy can be considered as a best treatment procedure. But that to have some complications like Decreased Shoulder ROM, Pain & Disabilities. To overcome these complications we can have physiotherapy protocol. But In India it is tough to have a physiotherapist in every rural area. So, this study is mainly focuses on the tele physiotherapy protocol and helps us to find out weather tele physiotherapy is helpful or not. So, after having this research study we have found out that the tele physiotherapy is helpful for reducing the complications like pain, ROM & Disabilities. So, for the patients who resides in rural area where physiotherapy facilities are not available, those patients can be benefited by having tele physiotherapy than compared to No Physiotherapy at all.

Keywords: Breast Cancer, Modified Radical Mastectomy, Tele – Physiotherapy

INTRODUCTION

Breast cancer is a growing concern in India, with increasing incidence and mortality rates[1].According to recent studies, breast cancer is the leading cause of mortality among women in India[1]. In fact, it is estimated that one in every 28 Indian women is at risk of developing breast cancer in her lifetime[2]. In light of the growing concern of breast cancer in India, it is essential to explore treatment options that can offer the best chance of recovery and long-term survival. One such option is the Modified Radical Mastectomy, a surgical procedure involving the removal of the entire breast, including the breast tissue, nipple, and sentinel lymph nodes[3]. After undergoing a Modified





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Radical Mastectomy, individuals may experience various complications that could impact their recovery and long-term well-being⁴. These complications can include lymphedema, a condition characterized by swelling in the arm on the side of the surgery, as well as limited mobility and discomfort^[4]. Additionally, some individuals may experience psychological distress, body image issues, and emotional challenges following the removal of the breast^[4]. In conclusion, physiotherapy after a Modified Radical Mastectomy is an essential component of comprehensive care for individuals diagnosed with breast cancer in India^[5]. It plays a vital role in improving physical function, emotional well-being, and overall quality of life after the surgery^[5]. By integrating physiotherapy into the post-operative care plan, healthcare providers can support individuals in their journey towards recovery and long-term well-being^[6]. Tele physiotherapy has emerged as a valuable option for individuals undergoing post-operative care, especially in the current global health crisis^[7]. In India, tele physiotherapy offers a convenient and effective way for individuals to receive physiotherapy services remotely^[8]. Through virtual consultations and guided exercises, individuals can access professional support from experienced physiotherapists without the need for in-person visits^[8]. Tele physiotherapy sessions can include guided exercises, movement assessments, and educational resources to empower individuals in actively participating in their recovery process^[9]. In conclusion, tele physiotherapy has emerged as a valuable tool for individuals undergoing post-operative care, particularly those recovering from breast cancer treatment in India^[9]. It provides convenient access to professional support, especially for those in rural or remote areas^[10]. Furthermore, it reduces the burden of travel and promotes a comfortable recovery environment at home^[10]. The use of tele physiotherapy in India has proven to be a significant advancement in delivering comprehensive care to individuals undergoing breast cancer treatment^[11].

METHODOLOGY

Here we have conducted this study to check about the effectiveness of tele physiotherapy in terms of ROM, Pain & Disability for the patients underwent for modified radical mastectomy. For this study we have selected patients underwent for modified radical mastectomy in the Amreli district of Gujarat during the period of Mar 2021 to Feb 2023. We have found total of 162 patients who underwent for the modified radical mastectomy but among of them we have selected only 138 patients as 24 patients either didn't match the inclusion criteria or they have denied participating in the study. Patients were selected for the study if they fulfil the following criteria. Female at the age of 25 to 70 years suffering with stage I -III breast cancer that was treated by modified radical mastectomy within last 3 months of period. Subjects were excluded from the study if they had a history of previous shoulder and neck surgery, neuro muscular skeletal conditions that may affect the shoulder and neck function, mental illness, subjects having any legal issues patients who did not understand the communication languages selected for the study (Gujarati, Hindi English) patient having cognitive defects that may interfere with the intervention and outcome. Before starting the study, we have given an introduction to all participants about the research and had taken written consent to participate in the study. A total of 138 patients had participated in the study and they had been given 2 choices;

1. They can stay at their home and can join the tele physiotherapy session regularly for 1 hour – Tele Physiotherapy Group – Group A
2. They can stay at home and perform a physiotherapy protocol as given in the pamphlet - Control group – Group B . So, among of those 138 patients, 70 patients have selected to join group A and 68 patients have selected to perform physiotherapy as per the pamphlet and joined group B.

INTERVENTION

Group A – Tele Physiotherapy Group

1. Active exercise and active mobilization to reduce lymphedema and active muscle contraction of upper limb muscles.
2. Active Exercises to improve the shoulder range of motion that includes Flexion, extension and hyper extension exercises either in sitting or in standing position.
3. Strengthening of the muscles of the shoulder girdle was provided either by using dumbbell and Thera bands.



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4. Functional activities were been educated for the upper limb like shifting objects from the floor to the cupboard, grooming activities, dressing activities, occupational activities and all other decided activities of the patient's choice which are feasible.
5. General aerobic exercises were provided to increase the cardio respiratory endurance and also to increase the chest wall expansion which might be altered following the surgery.
6. Endurance exercises were provided with less weight and more frequency of movement for of the upper limb.

Group B – Control Group

We have provided a pamphlet contain full physiotherapy treatment protocol similar to the physiotherapy protocol we given to tele physiotherapy group.

1. Self mobility exercise to reduce lymph edema in the form of active muscle contraction of upper limb muscles.
2. Self exercises to improve the shoulder range of motion that includes scapular mobility, stretching of the Latissimus dorsi, Serratus anterior, Deltoid and Pectoralis major.
3. Self strengthening of the muscles of the shoulder girdle was provided either using theraband or dumbbell.
4. Functional activities was be educated for the upper limb like shifting objects from the floor to the cupboard, grooming activities, dressing activities, occupational activities and all other decided activities of the patient's choice which are feasible.
5. General aerobic exercises were provided to increase the cardio respiratory endurance and also to increase the chest wall expansion which might be altered following the surgery.
6. Endurance exercises were provided with less weight and more frequency of movement for of the upper limb. The treatment duration is for 60 minutes concentrating equally all the components for 10 minute each and 5 times in a week. Rest was incorporated on a case-to-case basis as per the expertise of the researcher. – for both the groups. For the group A – A tele physiotherapy session has been conducted by zoom meeting every time. We have asked both the group patients to visit the physiotherapy clinic at the end of 1 month for the further assessment.

ANALYSIS

Here in this research, we have analysed the data by means of withing group analysis to check the effectiveness of treatment protocol and between group analysis to check which treatment protocol is superior among of two. For both the groups we have measured 3 different outcome measures of Pain, Flexion ROM & SPADI Score at 2 different intervals:

- i. Baseline, before starting the treatment – Pre-Test
- ii. 1 month post treatment – Post Test

Paired Sample t test had been performed for within group analysis for the pain in tele physiotherapy group and control group and it showed the significant difference between Pretest & Post test in both the groups with having p value of < 0.005 in both the group at every interval. Above result of within group Analysis shows that both the treatment protocol of tele physiotherapy & control group is effective for the treatment of pain in the patients underwent for the modified radical mastectomy

Within group analysis – ROM

Paired Sample t test had been performed for within group analysis for the flexion ROM in tele physiotherapy group and routine physiotherapy group and it showed the significant difference between Pretest & Post test. In both the group p value of < 0.005 is found. Above result of within group analysis shows that both the treatment protocol of tele physiotherapy & Control Group is effective for the treatment of improving flexion ROM in the patients underwent for the modified radical mastectomy



**Kalpeshkumar Vasani et al.,****Within Group Analysis – SPADI**

Paired Sample t test had been performed for within group analysis for the SPADI Score in tele physiotherapy group and Control group and it showed the significant difference between Pretest & Post test in both the group with p value of < 0.005 in both the group. Above result of within group comparison shows that both the treatment protocol of tele physiotherapy & Control Group is effective for the treatment of improving SPADI Score in the patients underwent for the modified radical mastectomy

Between Group Analysis – Pain

Independent Sample t Test had been performed to compare the effectiveness of treatment by means of reducing pain in both the groups and found no significance of difference in the value of pain at Pretest analysis with having F value of 2.74 and p value of > 0.005 . Independent Sample t Test had been performed to compare the effectiveness of treatment by means of reducing pain in both the groups and found a significance of difference in the value of pain at Post test with having F value of 2.09 and p value of < 0.005 . Above mentioned result showed that the Tele physiotherapy group was much more effective in reducing the pain than compared with Control group.

Between Group Analysis – Flexion ROM

Independent Sample t Test had been performed to compare the effectiveness of treatment by means of improving ROM in both the groups and found no significance of difference in the value of ROM at Pretest analysis with having F value of 0.68 and p value of > 0.005 . Independent Sample t Test had been performed to compare the effectiveness of treatment by means of improving ROM in both the groups and found a significance of difference in the value of ROM at Post Test with having F value of 5.15 and p value of < 0.005 . Above mentioned result showed that the tele physiotherapy group was much more effective in improving the ROM than compared with tele physiotherapy group.

Between Group Analyses – SPAD Score

Independent Sample t Test had been performed to compare the effectiveness of treatment by means of reducing SPADI Score in both the groups and found no significance of difference in the value of ROM at Pretest analysis with having F value of 0.54 and p value of > 0.005 . Independent Sample t Test had been performed to compare the effectiveness of treatment by means of reducing SPADI Score in both the groups and found a significance of difference in the value of SPADI Score at Post Test 2 with having F value of 0.19 and p value of < 0.005 . Above mentioned result showed that the tele physiotherapy group was much more effective in reducing the SPADI Score than compared with tele physiotherapy group.

DISCUSSION

Here in this study, we have collected the data and analysed it with having within group analysis and between group analysis and found that both the treatment protocol were effective by means of improving in Pain, ROM & SPADI score but while compared both the group result post treatment, we have found the tele physiotherapy group was much more effective than compared to Control group. In a developing country like India, we are facing a huge lack of healthcare workers especially in the rural areas. So, patients suffering from many conditions like having post operative complication of modified radical mastectomy couldn't receive a proper treatment because they don't have proper medical facility available at their home town So, in the era of 21st century, when we are having a proper technology like tele medicine and when the health & family welfare department of government of India is also promoting the tele physiotherapy. Then why can't we as a physiotherapist take a step forward in this direction & provide a tele physiotherapy to patients who are unable to come at clinic regularly. So, these types of patients can have a better life ahead. This study was to check the effectiveness of tele physiotherapy in the patients underwent the modified radical mastectomy and had been proved that tele physiotherapy can be a better option for the patients who can't go to the physiotherapy clinic regularly than having a no physiotherapy treatment at all. No doubt a tele





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physiotherapy can't be as much beneficial as the routing physiotherapy at physiotherapy clinic. But we can provide batter life for those patients who can't come for the routine physiotherapy at clinic regularly.

CONCLUSION

The results of the study suggest that, Tele Physiotherapy and Control Group both are beneficial for reducing pain, improving ROM and Reducing disability index for the patients underwent for modified radical mastectomy. Before starting the physiotherapy treatment, at Pretest analysis, we have found both the group were similar and have not found significantly different in the terms of pain, ROM & SPADI. Tele physiotherapy group was quite more beneficial while compared to Control group at Post Treatment analysis. According to the result we got after having data analysis, routine physiotherapy would always be having an upper hand than compared to tele physiotherapy, and it is preferred for the patients to take the physiotherapy regularly at physiotherapy clinic whenever itis possible. But while it is not possible for the patients to come at physiotherapy clinic regularly, it is preferred to have a tele physiotherapy at home and make a regular follow up at physiotherapy clinic whenever asked.

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Table:1 Paired Samples Test – TelePhysiotherapy Group

Paired Samples Test – TelePhysiotherapy Group								
	Paired Differences					T	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pre-test - Post Test	24.914	6.900	1.166	22.544	27.285	21.362	34	.000

Table:2 Paired Samples Test – Control Group

Paired Samples Test – Control Group								
	Paired Differences					t	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pretest - Post Test	40.618	8.038	1.378	37.813	43.422	29.466	33	.000

Table:3 Paired Samples Test – Tele physiotherapy Group

Paired Samples Test – Tele physiotherapy Group								
	Paired Differences					T	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pretest - Post Test	-46.314	8.109	1.371	-49.100	-43.529	-33.791	34	.000

Table:4 Paired Samples Test – Control Group

Paired Samples Test – Control Group								
	Paired Differences					T	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pretest - Post Test	-32.324	10.92	1.873	-36.134	-28.513	-17.259	33	.000





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Table:5 Paired Samples Test – Tele Physiotherapy Group

Paired Samples Test – Tele Physiotherapy Group								
	Paired Differences					t	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pretest - Post Test	39.771	6.044	1.022	37.695	41.848	38.927	34	.000

Table:6 Paired Samples Test – Control Group

Paired Samples Test – Control Group								
	Paired Differences					t	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pretest - Post Test	62.618	8.038	1.378	59.813	65.422	45.425	33	.000

Table 7: Independent Samples Test

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pretest	Equal variances assumed	2.738	.103	-.418	67	.677	-.680	1.625	-3.924	2.565
Post Test	Equal variances assumed	2.097	.152	14.26	67	.000	15.024	1.054	12.921	17.126

Table:8 Independent Samples Test

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper





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Pretest	Equal variances assumed	.684	.411	-.962	67	.339	-2.046	2.126	-6.290	2.197
Post Test	Equal variances assumed	5.152	.026	6.144	67	.000	11.945	1.944	8.064	15.825

Table 9: Independent Samples Test

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pretest	Equal variances assumed	.054	.817	-2.167	67	.034	-2.658	1.227	-5.107	-.209
Post Test	Equal variances assumed	.189	.665	14.959	67	.000	20.188	1.350	17.494	22.882





Green Manuring: A Miracle Solution for Reclaiming Saline and Sodic Soil

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ABSTRACT

One of the most significant challenges in modern agriculture is producing enough high-quality food grains to feed an ever-increasing population while safeguarding soil quality, fertility, and productivity. Now-a-days, many farmers use these agrochemicals and pesticides indiscriminately, resulting in loss of soil fertility and productivity as well as a harmful impact on human health. Gypsum has a long history of being used to control salt-affected soils; however, major barriers to its use, such as transportation, cost, and availability, prevent small and marginal farmers from adopting it. In this scenario, using green manure provides a glimpse of hope. Green manuring is a simple, cost-effective and environmentally friendly approach to managing these soils. Globally, there are several types of green manure crops that support soil nutrient dynamics and improve soil health.

Keywords: Fertility, Green manure, Gypsum, Soil health, Soil quality

INTRODUCTION

Current world population (7.3 billion) is further projected to increase to 8.5 and 9.7 billion during 2030 and 2050, respectively which is expected to stabilize at around 11.2 billion by the end of the twenty-first century. To achieve nutritional security, this growing population will necessitate increased food grain production from limited land and water resources. Food grain production expanded dramatically at the worldwide level during the twentieth century, leading in a massive yield rise due to a surge in net cultivable land. Additionally, the use of short-duration high-yielding cultivars, synthetic fertilizers, and pesticides is unavoidable (Sihag *et al.* 2015). This technique has resulted in the slow deterioration of soil organic matter as stable soil aggregates break down and organic matter decomposes.



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Consequently, soil health has deteriorated in terms of reduction in the water-holding capacity of soils, surface and groundwater pollution and multiple nutrient deficiencies. Overuse of nitrogenous fertilizer to boost agricultural productivity endangers the ecosystem. The use of chemical fertilizers in agriculture and different industrial units has caused an increase in atmospheric concentrations of reactive forms of nitrogen (e.g., NO, NO₂, N₂O, NH₃, etc.) by around 100% (Meena *et al.*, 2018). This scenario leads us to reexamine the role of biological nitrogen fixation, and the addition of legumes to green manure appears to be a viable response.

What is green manure crop?

Green, undecomposed plant material used as manure is called green manure. Green manuring is the technique of ploughing and incorporating undecomposed green plant tissue into the soil to improve soil fertility and production. It boosts soil fertility by adding nitrogen directly to the soil via symbiosis, as well as improving soil structure, water holding capacity, and microbial population through the addition of humus or organic matter. The green manuring practices are of two types- in-situ green manuring (short-duration - 45 to 60 days, crops are grown and incorporated into the soil at the same site) and ex-situ green leaf manuring (foliage and tender parts of green manuring crops collected from nearby forests, shrubs, and trees are incorporated into the soil at 15-30 days before the sowing of main crops). The herbaceous leguminous crops, namely dhaincha, sunhemp, cowpea, green gram, black gram, etc., and woody legumes, namely- subabul, gliricidia, karanja etc. can fix the atmospheric N in their root nodules.

Effect of green manure on salinity and sodicity

A significant number of soluble salts, such as Ca⁺⁺, Mg⁺⁺, and Na⁺ present in saline soil which affects plant growth, development, yield, and deteriorates seed quality owing to osmotic stress in the root zone (Shirale *et al.*, 2018). The use of green biomass raises the partial pressure of carbon dioxide and organic acids, triggering a spike in the release of salts into soil solution as an outcome of mineral dissolution. This allows salts to leach below the root zone, establishing an ideal environment for crops to thrive. When GM is introduced to salt-affected soil, it substantially boosts the levels of N, organic C, organominerals, and total carbohydrates in the soil (Zubair *et al.*, 2012). Soil pH decreases when organic acids (amino acid, glycine, cysteine, and humic acid) are produced during heterotrophic mineralisation of organic materials and autotrophic nitrification. During decomposition, the applied green manures release CO₂, which absorbs in water to form carbonic acid. This acid boosts the solubility of calcium carbonate minerals and increases the concentration of Ca²⁺ in soil solutions, which replaces Na⁺ on exchange complex and reduces the exchangeable sodium percentage (ESP) by lowering pH, dissolving calcium carbonate, and generating several kinds of complex calcium ion pairs. Because the sodium carbonate and sodium bicarbonate salts in the solution breakdown humus, especially the fulvic and humic acid portions, sodic soil has a low organic content (Khan *et al.*, 2000). Additionally, they facilitate the exchange sites' calcium-to-sodium ion exchange (Kumar *et al.*, 2020).

Sodic soil usually contains lime as insoluble calcium carbonate; hence it has lower calcium ionic activity. It has been demonstrated that two especially effective green manures (GM) and green leaf manures, respectively, to rehabilitate sodic soils are *Sesbania aculeata* and *Delonix elata*, both of which are resistant to sodicity stress (Baig and Zia, 2006; Chandrasekaran *et al.*, 2010). The following order was followed by the various green manures' levels of reclamation potential: dhaincha > sunhemp > cowpea > green gram (Shirale *et al.*, 2017). *Sesbania aculeata* may assist in replace sodium from sodic soils since it contains 34% calcium on a dry weight basis. Additionally, using green manure reduces the concentration of a number of cations and anions, such as Cl⁻, SO₄²⁻, HCO₃⁻, and CO₃²⁻ (Shirale *et al.*, 2018).

Conclusion: Using organic amendments to recover from salt stress strengthens soil health and food security. Green manure releases nutrients more quickly, is easier to decompose, has a higher N content and a lower C/N ratio, and minimises the risk of N immobilisation for subsequent crops. After decaying, exchangeable sodium in green manure crops is replaced with calcium, which reduces the pH of the soil, stimulates nutrient absorption, and boosts soil health for higher yields of crops. In order to restore soil fertility and production in saline and sodic soils, green manuring crops offer an economical and ecologically responsible solution.



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Unexpected Consequences: Facial Nerve Paralysis in Mandibular Trauma Cases: A Case Report

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ABSTRACT

Mandibular fractures are the second most common fracture in the face region. The main causes for this fracture are car accidents, personal violence, falls or bike falls. Facial nerve paralysis occur very commonly in head injuries where trauma to the temporal bone causes fracture of facial canal which can cause compression on nerve or may be tearing of nerve leading to paralysis. Despite this high prevalence, there is still controversy on how to manage it. Here we are reporting a rare case of facial nerve injury in a minimally displaced fracture of mandible. An 83-year-old female, involved in a road accident a month prior, presented with a history of unconsciousness. Initial examination revealed subdural hematoma (SDH) and facial fractures. The patient, initially managed with carbamazepine and no mandibular intervention, later developed neurological deficits. A month post-accident, she exhibited difficulty in eating, inability to close her left eye, and impaired facial expressions. CT imaging indicated a minimally displaced mandibular fracture. Prednisolone was prescribed without mandibular intervention. Facial nerve injury in minimally displaced mandibular fractures is a rare occurrence. Understanding the mechanisms and etiologies is crucial for appropriate management and prognosis assessment.

Keywords: Mandibular fractures; facial nerve injuries; facial paralysis



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INTRODUCTION

Mandibular fractures are the second most common fracture in the face region, second only to nasal fractures. The main causes for this fracture are car accidents, personal violence, falls or bike falls. Despite this high prevalence, there is still controversy on how to manage it. The literature reviews different ways to manage facial nerve injury post trauma is a rarely identified complication as facial nerve paralysis occur commonly in fracture of skull base, which is associated with other life threatening injuries. There have been only a few cases reported of facial nerve injury post mandibular trauma which is not associated with cranial injuries. Here we are reporting a rare case of facial nerve injury in a minimally displaced fracture of mandible

Case report

A 83 year old female patient reported to the department of OMFS, SGT University. Patient's relative gave a history of fall when she was hit by a vehicle on road 1 month ago. Patient became unconscious for 10 min. Patient was taken to PGIMS Rohtak where clinical examination and CT was done. CT revealed SDH and facial fracture. Patient was put on carbamazepine 200mg twice daily and was referred home without any intervention for mandibular trauma. Patient became neurologically deficit and was not identifying family and relatives after accident. 1 month later patient was brought to OMFS OPD in SGT university with a complain of inability to eat food and inability to close left eye by relatives only. The patient was not oriented to time, place and person and was barely following commands. On clinical examination, the occlusion was not disturbed, but patient was complaining of difficulty in chewing food. Patient was not able to close left eye or was not able to frown. (Fig-1: A, B, C) Salivary drooling was present from corner of mouth A repeat CT face and head was advised which revealed minimally displaced fracture of body of mandible and zygomatic arch. (Fig-2) No evidence of SDH was seen in the CT. Patient was advised a tapering dose of prednisolone without any intervention for facial fractures.

DISCUSSIONS

Facial nerve paralysis occur very commonly in head injuries where trauma to the temporal bone causes fracture of facial canal which can cause compression on nerve or may be tearing of nerve leading to paralysis. But, Facial nerve injury in mandibular fractures is rarely encountered due to its course and impact received by the mandible. Only a handful of cases of unilateral facial nerve palsy secondary to isolated mandibular fractures, i.e without associated temporal bone fractures, have been reported to date. Absence of neurological and otological findings as well as a normal CT scan suggested a peripheral cause for the lower motor neuron type of facial nerve palsy in this patient. Delayed onset of facial palsy has been reported after mandibular fractures. BRUSATI & PAINI authored vascular disturbances consequent upon oedema are probably the cause of delayed onset of facial paralysis[1]. In the present case, the facial palsy was noted on about 9th-10th day postoperative day. The mechanism of facial nerve injuries in mandibular fractures without associated temporal bone fractures or associated otological causes has been variously cited as:

1. oedema in the fallopian canal[2];
2. oedema and haemorrhage around the facial nerve in the region of the parotid gland[3];
3. traction injury to the nerve trunk at its exit from the stylomastoid foramen[1];
4. direct trauma from fractured stump ends[4];
5. vigorous manipulation for fracture reduction[5].

In this case the sudden splaying of the body fracture may have lead to cause traction injury to the facial nerve which might have caused facial paralysis. Although paralysis of all 5 branches of facial nerve is a rare entity in mandibular fracture. Other investigations including MRI, HIV and blood investigations were done to rule out other causes but none of them were associated with aetiology of this case. Secondary facial palsy, similar to other etiologies of facial paralysis, is considered to diminish by itself in a period of 3 to 6 months, with almost no permanent paralysis cases [6,7]. But regular follow ups are required to trace the recovery of nerve function and to identify etiology of paralysis





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in such cases. Scuto A, S. Cappabianca in a case report presented delayed post-traumatic facial nerve palsy without radiological evidence of temporal bone fractures, in which magnetic resonance was crucial for diagnosing the nerve impairment. Radiological findings in accordance both with electrodiagnostic tests and clinical presentation suggested the successful conservative management. They stated that delayed FNP is usually due to the pressure effect of a reversible edema within the fallopian canal, best managed by medical treatment. Important prognostic factors are the severity of FNP and timing of onset, with the degree of palsy (based on the House and Brackmann scale and electric testing) having a greater influence on recovery of function than the time of onset.[8,9] Some authors postulate a similar mechanism for this facial weakness as in Bell's palsy with a possible inflammatory reaction in and around the nerve, or a swelling of the nerve in the canal which could lead to ischemia. The vascular damage such as delayed arterial spasm, arterial or venous thrombosis, external compression from bony fragment or soft tissue edema are other etiological causes [10,11].

CONCLUSION

Facial nerve injury in minimally displaced mandibular fractures is a rare occurrence. Understanding the mechanisms and etiologies is crucial for appropriate management and prognosis assessment. Regular follow-ups and comprehensive assessments are essential for tracking nerve function recovery and identifying underlying causes of paralysis.

PATIENT CONSENT

Written informed consent was taken from the patient for the investigations, treatment and publication of their details.

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CONFLICT OF INTEREST

We declare that we do not have any commercial or associative interest that represents a conflict of interest in connection with the work submitted.

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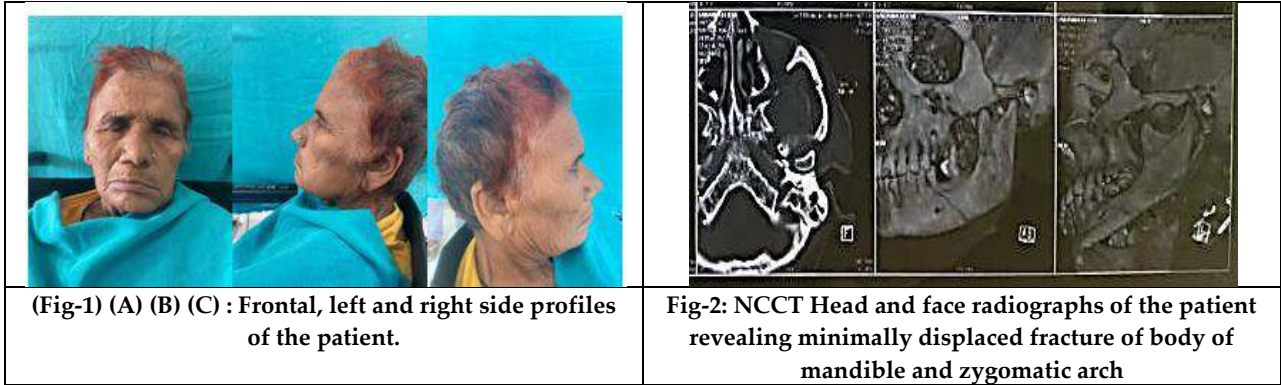
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Integrating Human Rights Education with Technological Ethics: Empowering Responsible Innovation and Societal Transformation

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ABSTRACT

This paper explores the integration of human rights education with technological ethics to propel responsible innovation and societal transformation. By examining the role of human rights education in the context of science and technology, the paper highlights how ethical considerations can be embedded in technological development to ensure that advancements contribute to social justice and human dignity. The study concludes with recommendations for educators, policymakers, and technologists on leveraging educational frameworks to promote human rights within the rapidly evolving technological landscape.

Keywords: Human Rights, Education, Innovation, Societal Transformation

INTRODUCTION

Human rights education plays a crucial role in building more equitable, just, and free societies, while fostering transformative societal change. It encompasses a range of educational practices and initiatives aimed at raising awareness, enhancing understanding, and cultivating respect for human rights principles and values. The importance of human rights education in nurturing a culture that respects human rights and in developing active, informed citizenship cannot be overstated. Its impact is evident in the dissemination of knowledge about rights and the development of skills necessary to defend and advocate for these rights. The significance of human rights education is widely recognized by international organizations and scholars within the human rights field. The United Nations has emphasized the importance of human rights education through various resolutions and declarations. Educational systems globally are often anchored in the principles of the Universal Declaration of Human Rights



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(UDHR); Article 26 specifically addresses education, stating that it "shall be directed to the full development of the human personality and to the strengthening of respect for human rights and fundamental freedoms" (United Nations, 1948). The United Nations Declaration on Human Rights Education and Training, adopted on December 19, 2011, further underscores the necessity of human rights education as essential for "achieving individual and collective life in dignity" and as a means to "promote equality, justice, sustainable development, social harmony, and peace" (United Nations, 2011). Human rights education can be delivered through both formal and non-formal approaches. Formal education systems, such as school curricula and educational institutions, provide a structured framework for imparting human rights knowledge and values. Non-formal methods, on the other hand, extend beyond traditional educational settings and include community-based initiatives, advocacy campaigns, online platforms, and grassroots efforts. These approaches aim to reach individuals in diverse contexts, including marginalized communities, addressing specific human rights issues and incorporating technological advancements to enhance learning (Osler & Starkey, 2005). Despite its potential, human rights education faces several challenges in its implementation. Obstacles such as conservative societal attitudes, political resistance from certain governments, and a lack of political will continue to hinder its inclusion in official curricula. Additional challenges include a lack of standardized approaches, inadequate teacher training, and limited resources (Andreotti, 2011; Bajaj, 2011). Overcoming these challenges requires concerted efforts and a multi-stakeholder approach involving governments, educational institutions, civil society organizations, and international bodies. Integrating technological ethics into human rights education can also play a crucial role in addressing these challenges by equipping learners with the tools to navigate the ethical implications of emerging technologies, thereby reinforcing the relevance of human rights in today's digital age

Conceptual Framework

Human rights education is a progressive endeavour aimed at instilling an understanding of fundamental human rights principles and values, fostering reverence for the inherent worth of every individual, and enabling people to actively advocate for and protect human rights. This comprehensive approach transcends the mere dissemination of information by cultivating critical thinking, acquiring practical skills, and fostering viewpoints and behaviors that align with human rights principles. The framework is presented in Figure (a).

Principles of Human Right Education

Human rights education is guided by fundamental principles that prioritize a rights-based approach to education. These principles aim to advance understanding, respect, and the implementation of human rights values across educational systems. The following key principles underpin human rights education, particularly in the context of technological advancement (Figure b)

- **Universality and Inalienability:** Human rights education emphasizes that human rights apply to every individual, regardless of race, gender, nationality, or any other distinguishing characteristic. These rights are inherent and cannot be revoked or denied, even as technology evolves. (UDHR, Article 1; United Nations, 1948)
- **Equality and Non-Discrimination:** Human rights education promotes equality and non-discrimination, highlighting the need for technologies that are inclusive and accessible to all, challenging discriminatory practices in their design and application. (Convention on the Rights of the Child, Article 2)
- **Participation and Empowerment:** Human rights education encourages active participation and engagement in decision-making processes, both in educational settings and the broader society. It empowers individuals to exercise their rights, promote social justice, and advocate for ethical technological innovation. (UNESCO, 1974)
- **Interconnectedness and Inseparability:** Human rights education emphasizes the interconnectedness of rights, ensuring that technological advancements do not infringe upon or compromise other human rights. Education should address the full spectrum of human rights to promote a holistic understanding and implementation. (World Conference on Human Rights, 1993)
- **Active Learning & Critical Thinking:** Human rights education employs active learning methodologies to engage learners in critical thinking and reflection, particularly regarding the ethical implications of technology.



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It promotes analysis of real-life human rights issues, fosters empathy, and develops skills for the peaceful resolution of conflicts. (UNESCO, 2017)

- **Respect for Diversity and Intercultural Dialogue:** Human rights education fosters respect for diversity and encourages intercultural dialogue, emphasizing the need for technology to respect cultural differences. It aims to develop an appreciation for different cultures, religions, languages, and perspectives, promoting tolerance, understanding, and the celebration of diversity. (Framework for Action on Education for Sustainable Development, UNESCO, 2014)
- **Social Responsibility & Global Citizenship:** Human rights education emphasizes social responsibility and global citizenship, encouraging individuals to recognize their role in creating a just and sustainable world. It advocates for the responsible use of technology to promote solidarity, active citizenship, and global engagement. (UNESCO, 2013)

These principles form the foundation for human rights education and guide its implementation in creating highly inclusive, equitable, and rights-respecting educational environments, particularly in an era of rapid technological change.

Importance of Integrating Human Rights Education across Educational Systems

Integrating human rights education across educational systems is of utmost importance, particularly in the context of technological advancements, for several reasons:

Respect for Human Dignity

Human rights education ensures that education itself respects and upholds the dignity of all individuals. It promotes a learning environment that is inclusive, non-discriminatory, and supportive of diversity, fostering a culture of respect for human dignity in the face of evolving technologies.

Empowerment of Individuals

Human rights education empowers individuals by equipping them with knowledge about their rights, enabling them to exercise agency, make informed choices, and advocate for themselves and others. It fosters critical thinking, empathy, and a sense of responsibility for promoting human rights, particularly in the ethical development and application of technology.

Promoting Social Justice and Equality

Integrating human rights education into educational systems helps to address systemic inequalities, discrimination, and social injustices. It equips learners with the tools to challenge oppressive structures and advocate for equal rights and opportunities for all, especially as technology reshapes societal norms.

Global Citizenship

Human rights education nurtures global citizenship by promoting understanding, empathy, and solidarity with individuals and communities beyond one's own national or cultural boundaries. It fosters a sense of shared responsibility for addressing global challenges, including those posed by emerging technologies, and promoting human rights worldwide.

Sustainable Development

Human rights Education shares a strong connection with the Sustainable Development Goals (SDGs) set forth by the United Nations. Integrating human rights principles into education contributes to achieving goals such as quality education, gender equality, peace and justice, and strong institutions, with an emphasis on the responsible use of technology in sustainable development. Integrating human rights education across educational systems is crucial for fostering a culture of respect, empathy, and active citizenship. It empowers individuals, promotes social justice, and nurtures a generation committed to upholding human rights and transforming societies toward a more inclusive, equitable, and technologically responsible future.



**Nishi Tyagi and Safia Mustafa****Empowering Individuals through Human Rights Education****Impact of Human Rights Education on Knowledge, Awareness, and Understanding**

Human rights education plays a pivotal role in equipping individuals with the knowledge of human rights principles, techniques, and approaches. It raises awareness of their own rights and the rights of others, fostering a deeper appreciation of the universality and indivisibility of human rights (Freire & Macedo, 1987). Through human rights education, individuals gain a comprehensive understanding of the historical, social, cultural, and technological factors that influence human rights breaches, enabling them to recognize and address systemic injustices (Pashby, 2017). Empirical research has demonstrated the positive impact of human rights education on knowledge and awareness. For instance, a study conducted in South Africa found that participation in human rights education programs significantly enhanced students' understanding of human rights, including specific rights such as the right to education and the right to a clean environment (Smit & Rensburg, 2019). Similarly, Merryfield (2011) revealed that human rights education led to significant improvements in students' understanding of human rights concepts, including discrimination and social justice, especially in contexts involving technological advancements.

Development of Critical Thinking, Empathy, and Respect for Diversity

Human rights education fosters the development of critical thinking skills, enabling individuals to analyze complex social and technological issues from a human rights perspective. It encourages individuals to critically reflect on their own beliefs and biases, challenging stereotypes and prejudices (Tibbitts, 2002). By examining real-life instances of human rights violations, particularly those exacerbated by technology, and actively participating in discussions and debates, individuals gain a more profound understanding of the underlying causes and impacts of discrimination, injustice, and technological inequalities. Furthermore, human rights education promotes empathy and respect for diversity. By learning about the experiences of marginalized and oppressed groups, including those affected by technological disparities, individuals develop a sense of empathy and a greater appreciation for the rights and dignity of all people (Briggs, 2008). Human rights education encourages individuals to embrace diversity and challenge discriminatory practices and attitudes in their communities, institutions, and the development of technology (Lombardo, 2011). Research has shown that human rights education enhances critical thinking, empathy, and respect for diversity. A study conducted in the Netherlands revealed that students who participated in human rights education programs demonstrated higher levels of critical thinking and empathy compared to those who did not receive such education (Kwakman, 2018). Similarly, McDonald & O'Connor (2018) found that human rights education programs positively influenced students' attitudes toward diversity, respect for human rights, and their understanding of technology's role in either perpetuating or alleviating inequality.

Promotion of Active Citizenship and Social Engagement

Human rights education empowers individuals to become active citizens who are engaged in addressing social issues and promoting positive change, particularly in the context of technology-driven societies. It encourages individuals to participate in civic activities, advocate for human rights, and contribute to the development of just, inclusive, and technologically responsible societies (Andreotti, 2006). Through human rights education, individuals develop the skills and confidence to take action at the local, national, or international level to uphold human rights principles and challenge violations, including those related to digital rights and technological ethics (Osler & Starkey, 2006). Studies have highlighted the transformative impact of human rights education on active citizenship and social engagement. For example, research conducted in Canada demonstrated that human rights education programs enabled students to critically examine social issues, develop leadership skills, and engage in community-based initiatives to promote human rights, particularly in addressing the ethical challenges of new technologies (Ghosh & Abdi, 2013). Minkenbergh (2015) found that human rights education contributed to young people's engagement in civil society organizations and activism, including those focused on technological justice.

Application of Human Rights in Everyday Life

Human rights education seeks to bridge the gap between theory and practice by enabling individuals to apply human rights principles in their everyday lives, including in their interactions with technology. It equips individuals with the knowledge and skills to identify human rights violations, assert their own rights, and support others in



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exercising their rights, particularly in digital and technological contexts (Owens & Murphy, 2012). Human rights education emphasizes the importance of respect, tolerance, and non-violence in interpersonal relationships, workplaces, communities, and online environments (Fuentes, 2018). Research has shown that human rights education enhances the application of human rights in various contexts. A study carried out in Sweden discovered that human rights education played a significant role in fostering democratic values and attitudes among students, leading to a stronger dedication to human rights in both their personal and professional lives, including their approach to technology use and development (Rosenberg, 2019). A study by Jain (2017) demonstrated that human rights education positively impacted individuals' attitudes and behaviors concerning gender equality and women's rights, with an emphasis on the role of technology in either supporting or hindering these rights. In summary, human rights education empowers individuals by enriching their knowledge, awareness, and understanding of human rights. It cultivates critical thinking abilities, empathy, and respect for diversity, promotes active citizenship and social involvement, and facilitates the application of human rights principles in everyday situations, including those involving technology. By embracing these empowering principles, human rights education aims to foster a fairer, more inclusive, and technologically responsible society.

Transforming Societies through Human Rights Education**The Role of Human Rights Education in Challenging Discriminatory Practices and Systems of Oppression**

Human rights education plays a crucial role in challenging discriminatory practices and dismantling systems of oppression within societies, especially in a world increasingly shaped by technology. By promoting an understanding of equality, dignity, and non-discrimination, human rights education empowers individuals to challenge and confront prejudices, stereotypes, and discriminatory behaviors, both online and offline (Andreotti, 2006). It encourages critical reflection on the structural and systemic barriers—including those embedded in technological systems—that perpetuate discrimination and inequality, fostering a commitment to social justice and human rights. Human rights education provides individuals with the tools and knowledge necessary to advocate for the rights of marginalized and oppressed groups, particularly in contexts where technology may exacerbate existing inequalities. It equips individuals with the skills to identify, address, and prevent human rights violations, working towards the creation of inclusive and just societies (Mertens & Jorna, 2018). Through awareness-raising, education, and community mobilization, human rights education empowers individuals to challenge discriminatory practices and advocate for systemic change, including ethical considerations in the design and application of technology.

Fostering Inclusive and Democratic Learning Environments

Human rights education fosters inclusive and democratic learning environments that prioritize the principles of equality, participation, and respect for diversity, while integrating these principles into the realm of technological ethics. By embedding human rights education into educational systems, institutions can create spaces where all individuals feel valued, respected, and included, regardless of their background or access to technology (Osler & Starkey, 2010). Human rights education promotes dialogue, critical thinking, and active participation, encouraging students to engage in meaningful interactions and collaborative problem-solving, including in digital and technologically mediated environments. In inclusive and democratic learning environments, human rights education enables individuals from diverse backgrounds to learn from one another, challenge biases, and build empathy. It nurtures a sense of belonging and ownership, empowering individuals to become active contributors to their communities and agents of change (UNESCO, 2016). By providing students with opportunities to voice their perspectives, particularly in the context of technological development and use, human rights education strengthens democratic principles and cultivates a culture of open dialogue, tolerance, and understanding.

Creating a Culture of Human Rights and Social Cohesion

Research has demonstrated the positive impact of human rights education on developing a culture of human rights and social cohesion, including in technologically driven societies. For instance, a study found that human rights education programs contributed to reducing prejudice and enhancing intergroup understanding among students from different religious and ethnic backgrounds (Dillenbourg et al., 2019). A study showed that human rights education initiatives in schools enhanced students' sense of belonging, acceptance, and inclusivity, leading to



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improved social cohesion (Navarro-Varas et al., 2020). Human rights education also plays a crucial role in addressing historical injustices and promoting reconciliation in post-conflict societies, as well as in addressing technological disparities that may contribute to new forms of injustice. By providing a platform for truth-telling, acknowledgment of past wrongs, and fostering empathy and understanding, it helps societies heal and move forward (Simic, 2014). For example, in South Africa, human rights education programs such as the Truth and Reconciliation Commission have been instrumental in promoting social cohesion and reconciliation in the aftermath of apartheid (Dugard, 2000). Furthermore, human rights education encourages individuals to actively engage in promoting human rights and social justice, including advocating for equitable access to technology and the ethical use of digital tools. It empowers individuals to confront institutional disparities, prejudice, and injustices using peaceful means (Friedman, 2018). By creating a sense of agency and a commitment to social change, human rights education develops a culture where individuals are driven to confront social challenges, including those related to technology, and contribute to building a more equal and inclusive society. In conclusion, human rights education is a significant instrument for developing a culture of human rights and social harmony, particularly in the context of a rapidly evolving technological landscape. It promotes values of equality, decency, and respect, enhances intergroup understanding and discussion, and contributes to correcting historical injustices and encouraging reconciliation. Human rights education provides individuals with the tools to actively engage in fostering a collective dedication to human rights, thereby establishing a framework for a society that upholds principles of justice, solidarity, and social cohesion, with a focus on ethical technological advancement.

Challenges and Opportunities in Human Rights Education**Challenges****Lack of Comprehensive Implementation**

Despite global recognition of its importance, many countries struggle to fully integrate human rights education into their formal education systems. This limits opportunities for learners to engage deeply with human rights principles and leaves significant gaps in knowledge, particularly in areas such as digital rights and technological ethics (Amnesty International, 2016).

Inadequate Teacher Training

Teachers often lack the necessary training and resources to effectively incorporate human rights education into their teaching practices. This gap is particularly pronounced in areas related to the ethical use of technology, where educators may be unfamiliar with the rapidly changing landscape of digital rights and responsibilities (Office of the UN High Commissioner for Human Rights, 2012).

Cultural and Contextual Sensitivity

Balancing universal human rights concepts with cultural and local issues remains a significant challenge. Ensuring that human rights education remains relevant and accepted across diverse cultural contexts is crucial, especially as technology introduces new dimensions to cultural and societal interactions (UNESCO, 2019).

Lack of Evaluation and Monitoring

The absence of comprehensive evaluation and monitoring frameworks hinders the ability to assess the impact and effectiveness of human rights education programs. This is particularly challenging in the digital space, where the outcomes of educational interventions may be less tangible and harder to measure (Human Rights Education Associates, 2011).

Opportunities**Integrating Human Rights across the Curriculum**

There is a significant opportunity to integrate human rights education into various subjects and disciplines, including science, technology, and digital literacy. By doing so, learners can explore human rights issues within diverse contexts, fostering a more holistic and interdisciplinary understanding of these principles (Amnesty International, 2016).



**Nishi Tyagi and Safia Mustafa****Technology and Digital Learning**

The rapid advancement of technology provides unique opportunities for innovative approaches to human rights education. Digital platforms, online courses, interactive resources, and virtual simulations can make human rights education more accessible, engaging, and relevant, especially for younger generations who are digital natives (UNESCO, 2020).

Community Engagement and Participatory Approaches

Involving learners in decision-making and action-taking processes empowers them to become agents of change within their communities. Technology can facilitate this engagement by providing platforms for collaboration, advocacy, and civic participation, allowing learners to take an active role in promoting human rights locally and globally (UNESCO, 2019).

Partnership and Collaboration

Collaboration among various stakeholders—including educational institutions, civil society organizations, technology companies, and governments—can enhance the implementation of human rights education. By sharing expertise, resources, and best practices, these partnerships can strengthen the global impact of human rights education and ensure it remains relevant in a technologically advanced world (Amnesty International, 2016).

Empirical Evidence and Case Studies in Human Rights Education**Research Studies on the Impact of Human Rights Education on Individuals and Communities**

Numerous research studies have explored the effects of human rights education on individuals and communities, providing empirical evidence of its effectiveness. These studies indicate that human rights education positively enhances knowledge, awareness, attitudes, and behaviors related to human rights issues, including those in the context of technological advancements. For instance, a study by Bringle and Hatcher (2012) examined the impact of human rights education on college students' attitudes and behaviors. The findings revealed that students who received human rights education demonstrated increased awareness of human rights issues and reported higher levels of engagement in activities promoting human rights, particularly in digital and technological contexts. In a meta-analysis conducted by Juvonen et al. (2020), the impact of human rights education on students' knowledge, attitudes, and skills was investigated. The findings showed that interventions in human rights education significantly enhanced students' knowledge and understanding of human rights, promoted greater empathy towards marginalized groups, and nurtured a stronger dedication to social justice, especially in relation to emerging technologies and digital rights.

Successful Examples of Integrating Human Rights Education in Educational Institutions

Several educational institutions have successfully integrated human rights education into their curricula, offering valuable insights into effective implementation strategies. These examples highlight the transformative potential of human rights education in fostering a culture of rights, social responsibility, and ethical technological engagement. One such example is the Raoul Wallenberg Comprehensive High School in Sweden. This school has embedded human rights education across all subjects, incorporating human rights themes into the curriculum, classroom activities, and school policies. This approach has led to improved student engagement, critical thinking skills, and a school culture rooted in respect for human rights, including an understanding of the ethical implications of technology (Nygren, 2018). Another successful case is the Human Rights Friendly Schools project in South Africa. This initiative supports the integration of fundamental rights education through teacher training, curriculum development, and the establishment of democratic and inclusive learning environments. The project has been associated with increased student participation, improved school atmosphere, and enhanced knowledge and comprehension of human rights principles, including those related to technological access and equity (Human Rights Friendly Schools, n.d.).



**Nishi Tyagi and Safia Mustafa****Lessons Learned and Key Findings from Empirical Research and Case Studies**

Empirical research and case studies in human rights education have provided valuable lessons and key findings for effective implementation, particularly in the context of technology. Firstly, it is essential to adopt a learner-centered approach that encourages active engagement and participatory learning. Empirical evidence consistently highlights the positive impact of interactive and experiential teaching methods in enhancing knowledge, attitudes, and skills related to human rights, including digital rights and technological ethics (Freire, 2018). Furthermore, the integration of human rights education across different subjects and grade levels facilitates a comprehensive understanding of human rights and their applicability in diverse contexts, including technological ones. By incorporating human rights themes into various disciplines, students gain a multidimensional understanding of human rights and recognize their interrelationships with various facets of life, including technology (Bourn, 2020). Moreover, establishing partnerships and fostering collaborations among educational institutions, civil society organizations, and government entities is crucial for the sustained integration of human rights education. These collaborative efforts enable the sharing of resources, capacity-building, and the exchange of successful approaches, thereby bolstering the effectiveness of human rights education initiatives, particularly in adapting to technological challenges (UNESCO, 2017). Empirical evidence and case studies offer valuable perspectives on the influence of human rights education and effective implementation approaches. Research findings reveal the beneficial outcomes of human rights education on individuals and communities, while case studies present exemplary models of integrating human rights education within educational institutions. These studies provide important lessons learned and key insights that inform the design and implementation of impactful human rights education programs, with a focus on the ethical use of technology.

Recommendations for Policy and Practice in Human Rights Education**Policy Implications for Integrating Human Rights Education in Educational Systems**

Integrating human rights education into educational systems requires supportive policies and frameworks that prioritize its inclusion. Policymakers play a crucial role in creating an enabling environment for the effective implementation of human rights education. One key policy recommendation is the development of national curricula that explicitly incorporate human rights education across all levels of education. This ensures a systematic and comprehensive approach to teaching human rights principles, values, and skills (Council of Europe, 2018). Policymakers should also allocate adequate resources for the development of relevant educational materials, teacher training programs, and evaluation mechanisms (Biswas, 2017). Additionally, policies should promote inclusive and participatory approaches to education, fostering a culture of respect for diversity, equality, and human rights within schools. This includes addressing discriminatory practices, promoting inclusive learning environments, and empowering students to participate in decision-making processes (UNESCO, 2015).

Strategies for Teacher Training and Professional Development in Human Rights Education

Teacher training and professional development are vital for developing the willingness of educators to effectively incorporate constitutional rights education throughout their teaching practice. Firstly, pre-service and in-service teacher training programs should incorporate comprehensive modules on human rights education, providing teachers with the necessary knowledge, skills, and pedagogical approaches. This training should focus not only on theoretical foundations but also on practical strategies for implementing human rights education in diverse classroom settings (OHCHR, 2012). Furthermore, professional development opportunities should be provided to educators on an ongoing basis. This can include workshops, seminars, and collaborative learning platforms that facilitate the exchange of best practices, resources, and experiences. Peer support networks and mentorship programs can also contribute to the professional growth of teachers in the field of human rights education (Bourn, 2020).

Collaborative Efforts and Partnerships to Advance Human Rights Education

Collaboration and partnerships among various stakeholders are crucial for advancing human rights education and creating a sustainable impact. Firstly, a collaboration between educational institutions, civil society organizations, and government agencies is essential. These partnerships can facilitate the development of joint initiatives, resource-sharing, and the coordination of efforts to integrate human rights education into policies and programs (United



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Nations, 2011). Additionally, collaboration with international organizations and networks can provide valuable support and expertise in advancing human rights education. These partnerships can contribute to the development of global standards, sharing of best practices, and advocacy for the importance of human rights education on the international stage (Council of Europe, 2010). Moreover, fostering collaboration at the local level, including community organizations, human rights advocates, and parents, can help create a supportive environment for human rights education. Engaging the wider community in dialogue, awareness-raising campaigns, and participatory activities can strengthen the impact of human rights education beyond the confines of the classroom (Biswas, 2017). Recommendations for policy and practice in human rights education include the development of supportive policies, comprehensive teacher training, and collaborative efforts among stakeholders. These recommendations emphasize the importance of integrating human rights education into national curricula, providing teachers with the necessary skills, and fostering partnerships to advance human rights education at all levels of society. Human rights education has emerged as an empowering tool that brings about transformative change, fostering a culture of respect for human rights and empowering individuals. This summary highlights the crucial discoveries and contributions in the field, emphasizing the importance of ongoing research, evaluation, and collective action.

Recommendations for Policy and Practice in Human Rights Education**Policy Implications for Integrating Human Rights Education in Educational Systems**

Integrating human rights education into educational systems requires supportive policies and frameworks that prioritize its inclusion, particularly in relation to technology and digital ethics. Policymakers play a crucial role in creating an enabling environment for the effective implementation of human rights education. One key policy recommendation is the development of national curricula that explicitly incorporate human rights education across all levels of education, including a focus on digital rights and technological ethics. This ensures a systematic and comprehensive approach to teaching human rights principles, values, and skills (Council of Europe, 2018). Policymakers should also allocate adequate resources for the development of relevant educational materials, teacher training programs, and evaluation mechanisms, particularly those that address the challenges posed by emerging technologies (Biswas, 2017). Additionally, policies should promote inclusive and participatory approaches to education, fostering a culture of respect for diversity, equality, and human rights within schools. This includes addressing discriminatory practices, promoting inclusive learning environments, and empowering students to participate in decision-making processes, especially those related to technology use and digital citizenship (UNESCO, 2015).

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Teacher training and professional development are vital for equipping educators to effectively incorporate human rights education throughout their teaching practice, especially in the context of technological change. Firstly, pre-service and in-service teacher training programs should incorporate comprehensive modules on human rights education, providing teachers with the necessary knowledge, skills, and pedagogical approaches, including those related to technological ethics. This training should focus not only on theoretical foundations but also on practical strategies for implementing human rights education in diverse classroom settings, with an emphasis on digital literacy (OHCHR, 2012). Furthermore, professional development opportunities should be provided to educators on an ongoing basis. This can include workshops, seminars, and collaborative learning platforms that facilitate the exchange of best practices, resources, and experiences, particularly in relation to technology. Peer support networks and mentorship programs can also contribute to the professional growth of teachers in the field of human rights education (Bourn, 2020).

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Collaboration and partnerships among various stakeholders are crucial for advancing human rights education and creating a sustainable impact, particularly in the context of technological advancement. Firstly, collaboration between educational institutions, civil society organizations, and government agencies is essential. These partnerships can facilitate the development of joint initiatives, resource-sharing, and the coordination of efforts to integrate human



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rights education into policies and programs, including those related to technology and digital rights (United Nations, 2011). Additionally, collaboration with international organizations and networks can provide valuable support and expertise in advancing human rights education. These partnerships can contribute to the development of global standards, sharing of best practices, and advocacy for the importance of human rights education on the international stage, especially in addressing the global challenges posed by technology (Council of Europe, 2010).

Moreover, fostering collaboration at the local level, including community organizations, human rights advocates, and parents, can help create a supportive environment for human rights education. Engaging the wider community in dialogue, awareness-raising campaigns, and participatory activities can strengthen the impact of human rights education beyond the confines of the classroom, particularly in promoting ethical technology use and digital citizenship (Biswas, 2017).

Importance of Ongoing Research and Evaluation in Human Rights Education

Ongoing research and evaluation efforts are crucial for understanding the impact and effectiveness of human rights education initiatives, especially in the rapidly evolving technological landscape. Through rigorous investigations and assessment mechanisms, scholars and practitioners have provided valuable insights into the outcomes, methodologies, and recommended approaches of human rights education. Research has established that human rights education positively improves knowledge, understanding, attitudes, and behaviors related to human rights concerns. It develops critical thinking abilities, empathy, respect for diversity, and active citizenship among learners, with significant implications for digital literacy and ethical technology use. Successful case studies have demonstrated strategies for integrating human rights education in educational institutions, highlighting the transformative potential of such programs in both traditional and digital environments. Ongoing research and evaluation contribute to improving and refining human rights education practices. They identify effective teaching methods, curriculum design, and assessment approaches, paving the way for evidence-based pedagogical strategies that address the challenges of integrating technology and human rights. Evaluation frameworks enable practitioners to assess intervention impacts, identify areas for improvement, and ensure accountability and quality assurance, particularly in digital learning contexts.

Call to Action for Promoting Human Rights Education as a Transformative Tool

The findings and contributions in human rights education necessitate collective action to promote its integration and advancement as a transformative tool, especially in the context of technological change. Firstly, policymakers should prioritize human rights education in national agendas, curriculum frameworks, and educational policies. Recognizing human rights education as a fundamental aspect of quality education is essential, ensuring its inclusion and integration at all educational levels, with a focus on digital rights and technological ethics. Adequate resources should be allocated to support the development of human rights education materials, teacher training programs, and monitoring mechanisms that address both traditional and digital learning environments. Secondly, educators and teacher training institutions play a critical role in promoting human rights education. They should actively engage in professional development opportunities, ensuring their competencies in delivering human rights education, particularly in relation to technology. This includes incorporating human rights principles and values into teaching practices, creating inclusive learning environments, and adopting participatory and experiential teaching methods that integrate digital literacy. Furthermore, coordination among stakeholders is vital for advancing human rights education. Partnerships between educational institutions, civil society organizations, governments, and international organizations can enhance knowledge sharing, capacity-building, and advocacy for the importance of human rights education, particularly in the face of technological challenges. Through joint actions, stakeholders can magnify their impact, promote systemic change, and create a broader influence in promoting human rights in both physical and digital spaces. In conclusion, the significance of continuous research, evaluation, and collaborative action in human rights education cannot be overstated. Continuous research enhances our understanding of its impact, while evaluation ensures ongoing development and adaptation to new challenges, particularly those posed by technology. Policymakers, educators, and stakeholders are urged to prioritize, integrate, and promote human rights education as a transformative instrument. By doing so, we can empower individuals, reform societies, and build a culture of respect for human rights, both in the physical world and in the digital age.





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Figure 1:(a) Empowering individual and transforming society with Human Rights Education



Figure 1 b: Key Principles of Human Rights Education





Watershed Cerebral Infarct Specific Physiotherapy Intervention – A Case Report

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ABSTRACT

Watershed cerebral infarct is a rare type of ischemic stroke involving the border zones of brain which could be cortical/external infarct or subcortical/internal infarct. Internal watershed cerebral infarct has a poor prognosis clinically. Specific physiotherapy intervention with action observation priming and task oriented approach have shown better recovery in rehabilitation of stroke patients. This case report analyzes the effect of specific physiotherapy intervention with action observation priming and task oriented training following internal watershed cerebral infarct.

Keywords: watershed cerebral infarct, physiotherapy, task oriented training, action observation priming.

INTRODUCTION

Watershed cerebral infarct is an ischemic stroke that occurs in the brain tissues bordering two main arteries such as the anterior cerebral artery (ACA) and the middle cerebral artery (MCA) or MCA and posterior cerebral artery (PCA). These areas are known as border zones and are located far away from the main arteries in brain [1]. It accounts for approximately 5-10% all the cerebral infarctions which occurs mainly in the elderly age groups [2]. Two types of watershed/ border zone infarct have been identified - external (cortical) & internal (subcortical) where external infarct is caused by embolism and internal border zone infarct is caused by hypoperfusion in presence of severe arterial stenosis or occlusion leading to an increased susceptibility to ischemia.[3,4].The typical clinical presentation is progressive, fluctuating or episodic decrease of motor control of upper limb and lower limb, motor aphasia associated with focal seizures which is more frequent in cortical watershed infarct than sub cortical infarct



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[5,6]. Bilateral border zone infarctions between the ACA/ MCA territories can produce predominantly proximal muscle weakness in the upper limb ("man in the barrel" syndrome), which is caused by bilateral symmetric damage isolated to the upper extremity motor fibers in the motor cortex, corona radiata, internal capsule, and basal ganglia [7]. Although the symptoms are similar to that of other ischemic stroke, it is very challenging to diagnose watershed infarcts as they develop slowly with milder symptoms over a period and are probably underestimated. Prognosis of the watershed stroke is rarely fatal but can cause severe disability and literature has shown poor prognosis for the internal watershed infarct clinically, at 3months [8,9]. Motor recovery following stroke is enhanced by various therapeutic interventions but specific physiotherapy intervention strategies such as task oriented approaches bring about better motor recovery following stroke at individual territories [10,11]. This case report analyses the effect of specific physiotherapy with Action Observation Priming (AOP) and Task-Oriented Training(TOT) intervention following MCA-ACA internal watershed cerebral infarct.

CASE REPORT

A 71 years old female, with right hand dominance was admitted in Neuro-ICU, Sri Ramachandra Hospital, Chennai. She had presented with the complaints of difficulty in using right upper and lower limb and difficulty in speaking and difficulty in performing activities of daily living. The subjective history of patient from the family members showed that patient was apparently normal till the day of stroke. On the day of stroke occurrence, when her daughter woke her up, she did not respond for a while after which blood pressure reading was taken using a home kit and found to have decrease in BP. Her daughter observed difficulty in changing her position in lying involving her right upper and lower limb. Immediately she was taken to a nearby hospital and admitted in emergency department. CT/MRI brain was taken to confirm the diagnosis and emergency medications were given. After getting the suggestion of consultant physician, she was brought to Sri Ramachandra Hospital, Chennai for further treatment. She had a past medical history of systemic hypertension with irregular medication and recently she was diagnosed as type 2 diabetes mellitus. As soon as she was stabilized with medications and found clinically normal, she was shifted to Sri Ramachandra Rehabilitation centre for further rehabilitation.

CLINICAL FINDINGS

On observation, right shoulder was adducted, internally rotated, elbow extended and wrist and hand was in neutral position; right hip adducted, knee extended and ankle was in plantar flexion in lying position. On palpation, muscle consistency was firm with no gross abnormalities. On examination of higher mental functions, the patient was alert, comprehending, oriented to time, place and person, level of attention and memory was good but showed motor aphasia. Motor examination components of Tendon jerks, muscle tone using Modified Ashworth Scale and Stage of voluntary control were assessed on the first day and findings are mentioned in the Table 1,2 and 5 respectively. In the first week of admission into the rehabilitation centre, postural control in sitting was poor and was able to assume only chair-sitting posture. Transition of positions from lying to sitting and standing was done with maximal assistance. Walking ability was poor. Her upper limb motor control and hand functions were poor. Outcome measures like Motor Assessment Scale, Brunnstrom stages of recovery were evaluated pre and post -intervention as shown in Table 4 & 5

CLINICAL INVESTIGATIONS

MRI-brain revealed multiple acute infarcts in left parasagittal frontal, parietal, temporal and occipital lobes suggestive of left internal watershed cerebral infarct of ACA/MCA territory. CT-angiogram showed complete non-opacification of left internal carotid artery from origin to the petro-cavernous segment suggestive of occlusion with delayed opacification in the cavernous supra clinoid segment and middle cerebral artery from the Circle of Willis.

PHYSIOTHERAPY INTERVENTION

The specific intervention protocol was designed according to the patient's needs and limitations. It included conventional physiotherapy exercise along with AOP and TOT. AOP was added prior to TOT in order to have better understanding of the movement to be performed and to enhance the motor performance. AOP was delivered as live demonstration of functional task to be trained in front of the patient by the therapist. Only one task per day was



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practiced with sufficient number of repetitions of AOP by the therapist. Each session lasted for about 50 minutes including the 20 minutes of conventional physiotherapy. Task was observed for two minutes in the observation phase of live demonstration by the therapist, followed by three minutes of action phase where the patients imitates and tries to execute the task with her paretic limb. This sequence was repeated for three times followed by rest and repetition of the entire sequence again. Motor learning was enhanced by verbal feedback given appropriately to maximize the performance. Complexity of the task increased as the patient improved and the same protocol was continued for 8 weeks. The tasks provided in various positions during the interventions are described in Table 3

RESULTS

Motor Assessment Scale (MAS) showed significant improvement in the gross motor activities and recovery in affected upper limb and lower limb after eight weeks of intervention. Pre and post intervention scores of MAS showed a change of 20 point difference. Brunnstrom recovery stages of arm, hand and leg showed significant improvement as shown in Table4 and 5

DISCUSSIONS

Watershed cerebral infarct is one of the ischemic type of stroke affecting the border zones of the tissues supplied by the anterior, middle and posterior cerebral arteries [12] The causes of watershed infarct might be an embolic or due to hypoperfusion and studies show that age group, impaired cardiac wall contractility, presence of cardiac thrombus and ulcerative cardiac plaque could determine the cause and type of watershed cerebral infarct [13]. Studies reveal that prognosis of internal watershed infarcts are poor than the external watershed infarcts at 3 months of duration [14]. AOP and TOT intervention enhances neuroplasticity by promoting activation of damaged motor circuits and creating new areas of cortical control and thereby improving motor learning process and performance of activities [15,16]. In addition, AOT provides a standard method of performing the task which acts as reference preventing compensation and demanding the use of maximal motor control with adequate visual feedback. Prognosis of our patient with internal watershed cerebral infarct of left (MCA-ACA) territory with right side involvement was fairly good at eight weeks with voluntary movements on Brunnstrom staging showing isolated movement patterns in upper limb, lower limb and hand. Motor assessment scale showed considerable change in performance of activities which could be attributed to improved motor learning with AOP and TOT approach. Though the activities of daily living were not measured quantitatively, patient was able to transform slowly from complete dependency to partially independent level.

CONCLUSION

We conclude that providing the specific intervention of AOP and TOT improves motor recovery of affected limbs by the enhancing motor control and motor relearning process which could absolutely result in increased functional performance. In this internal border zone case analysis, the outcomes became favourable after eight weeks of physiotherapy interventions which encourages to plan and incorporate AOP and TOT strategies for appropriate patients.

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CONFLICTS OF INTEREST

None declared



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Table 1: Deep Tendon Reflexes

DEEP TENDON REFLEXES	RIGHT	LEFT
BICEPS	Brisk	Normal
TRICEPS	Brisk	Normal
BRACHIORADIALIS	Brisk	Normal
KNEE	Exaggerated	Normal
ANKLE	Brisk	Normal

Table 2: Muscle Tone - Modified Ashworth Scale

MUSCLE TONE	RIGHT	LEFT
Shoulder flexors	1+	Normal
Elbow flexors	1+	Normal
Wrist and finger flexors	1	Normal
Hip flexors	1+	Normal
Knee flexors	1+	Normal
Ankle plantar flexors	1	Normal

Table 3: Physiotherapy Intervention

	TASKS TO BE PERFORMED
Upper limb	<ul style="list-style-type: none"> • Wiping the table with an extended elbow using towel • Turning a page • Stacking cups one over the other • Grasping & releasing a tennis ball • Unscrewing a lid of bottle • Holding and bringing the glass to the mouth • Eating with spoon
Lower limb	<p>Sitting - ball kicking using paretic lower limb</p> <p>Standing - inside the parallel bar then placing the foot on the ball and down.</p> <ul style="list-style-type: none"> - kicking the ball using her paretic lower limb - Placing the foot in forward, backward and Sideways <p>Walking - Over the foot marks labelled on the ground</p> <ul style="list-style-type: none"> - On various surface levels - Obstacle crossing <ul style="list-style-type: none"> - Gait training using cones and ladder - Stair climbing upwards and downwards





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Figure:1 Kicking the ball



Figure:2 Wiping the Table using Towel





***In vitro* and *In silico* Study of the Plant Extract of *Sauropus androgynous* with the Evaluation of It's Antibacterial and Antioxidant Properties**

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ABSTRACT

This study's objective was to use a disc diffusion assay to ascertain the *in vitro* antibacterial activity of the chloroform extract of *Sauropus androgynous* leaves against various harmful bacterial strains. Comparing the zone of inhibition created by plant chloroform extracts to standard antibiotic discs revealed marginally significant antibacterial activity. MIC has also been assessed. Additionally, the total phenol content has been quantitatively estimated using the Folin-Ciocalteu method, which employed gallic acid as the reference. The peroxide approach has also been used for antioxidant research. The formulation of herbal extract gel took into account its physicochemical properties. Biovia Discovery Studio was used to investigate the reported phytochemicals' molecular docking with the enzyme. With the aid of the HDock server, the interaction's strength was assessed. After the docking process, the lowest score values and most significant confidence values demonstrated a good ligand receptor binding process.

Keywords: In-silico study, HDock, Phenolic content, Folin- Ciocalteu method, *Sauropus androgynous*.





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INTRODUCTION

Indian traditional medicine is renowned for its long history of employing therapeutic herbs. A number of ethnomedicines have been discovered as a result of years of research into good health, long life, and relief from pain and discomfort. Various medical systems, including Ayurveda, Unani, Allopathy, and Homoeopathy, use plants as remedies [1,2]. Numerous novel therapeutically effective medications, such as anticancer medications or antimicrobials, have been developed from these medicinal plants [3-6]. Compared to current chemotherapeutic methods, the use of plants for healing and as a source of antimicrobials has many advantages [6, 7]. According to studies [8–11], a variety of medicinal plants are an excellent source of bioactive substances like peptides, glycosides, alkaloids, saponins, terpenoids, flavonoids, and phenols, the majority of which have antibacterial activity. The hunt for novel medicinal/bioactive molecules, particularly from plants, has been sparked by the antibiotic resistance of infections and the severe side effects of antibiotic use [12]. Biofilm development is one of the pathways that can lead to antimicrobial resistance. The antibiofilm activity of numerous plant-based compounds has been investigated, and the alternative usage of natural antibiofilm agents has grown in significance [13, 14]. Plant extracts have been proven in studies to limit the growth of harmful bacteria or prevent the formation of biofilms [15, 16]. Due to their safety and lower toxicity, chemicals produced from plants have been discovered to have potential applications in medicines [14–17]. The multivitamin plant, *Sauropus androgynous*, is a good source of carotenoids, vitamins A, B, C, and K. Many conditions are widely treated with various portions of *S. androgynous*, including fever, diabetes, cancer, high cholesterol, allergies, UTIs, and earaches [18–20]. Since the diverse therapeutic characteristics of these plants may have an additive or synergistic effect on one another, extracts of them are frequently used to make raw medicines [12]. A review of the literature reveals that no studies about the antibiofilm activity of *S. androgynous* leaf extracts have been published to yet. In order to assess the phytochemical components, antioxidant and antibacterial capabilities of *S. androgynous* leaf extracts, the current study effort was created.

MATERIALS AND METHODS

Materials

Methanol (Merck, India), Ethanol (Lobachem, India), Chloroform (Lobachem, India) were used during the extraction process. Gallic Acid (Lobachem, India) and Folin- Ciocalteu Reagent (Lobachem, India) had been used for the phenolic content estimation of the extract and Hydrogen Peroxide (Merck, India) was used for the antioxidant study by peroxide method. Hydroxy Propyl Methyl Cellulose (Lobachem, India), Propylene Glycol (Lobachem, India), Propyl Paraben (Lobachem, India), Methyl Paraben (Lobachem, India) were used for the formulation of herbal extract. Chloroform extracts were tested against a panel of 4 pathogenic bacterial strains including *Staphylococcus aureus* MTCC 96, *Bacillus subtilis* MTCC 441, *Escherichia coli* MTCC 443 and *Pseudomonas aeruginosa* MTCC 424 were purchased from Institute of Microbial Technology, Sector 39, Chandigarh, India.

Collection and Extraction of plant material

The plant sample i.e. leaves was collected from an herbal garden situated on Shyamnagar, West Bengal and were air dried under shade at room temperature, ground with electric grinder into fine powder and stored in air tight container for further use. Powdered sample was mixed with methanol: water of 4:1 ratio (solvents) for extraction in 1:1 ratio. After that the material was filtered by using Whatman No.1 filter paper and the filtrate was mixed with (2-3) drops of 2M HCl and then mixed with the equal volume of chloroform as same as of filtrate. After the formation of bottom organic layer, it was taken and separated followed by evaporation of the solvent for obtaining the dried residue. The resulting chloroform extract solution was used for further antibacterial and antioxidant activity [21].

Phytochemical screening of Extract

Terpenoids Test: The Salkowski test determines the presence of triterpenoid by forming a reddish-brown colour at the interface when dry extract is combined with water and a few drops of concentrated H_2SO_4 .





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Alkaloids Test

A good outcome is indicated by the production of a reddish-brown precipitate after adding 1 ml of Dragandroff's reagent to 2 ml of the filtrate.

Wagner's test

When 2 ml of extract are combined with a few drops of Wagner's reagent, a reddish brown precipitate forms to indicate a successful reaction.

Hager's test

A positive result is shown by the production of a yellow-colour precipitate when 2 ml of extract is combined with a few drops of Hager's reagent.

Mayer's test

A positive result is confirmed if a creamy precipitate forms after mixing 2 ml of extract with a few drops of Mayer's reagent.

Glycosides Test

If the extract yields a positive result in either of the Fehling (Fehling test A and Fehling test B) solutions, glycosides are present.

Flavonoids Test

Ammonium test: Layer separation was possible when the extract filtrate was combined with a diluted (1 ml, 1% v/v) ammonia solution. A favourable outcome is indicated if the ammonia layer is yellow.

Alkaline test

A favourable outcome is indicated by the dark yellow substance that turns colourless when diluted hydrochloric acid is added to the extract (2 ml) after being treated with a few drops of a 20% (w/v) sodium hydroxide solution.

Steroids Test and Salkowski test

A positive result was achieved when 2 ml of extract, 2 ml of chloroform, and 2 ml of concentrated sulphuric acid were added. If the chloroform layer was red and the acid layer was yellow-green fluorescence, the test was successful. Ferric chloride test for phenols: If the extract was treated with 3–4 drops of a 10% (w/v) ferric chloride solution and the appearance of a black green colour was noted, phenolic compound was present [22].

Quantitative analysis of total Phenolic content

Quantitative analysis of total phenolic in extracts was determined with the Folin- Ciocalteu reagent. Standard used for the analysis was Gallic acid. Concentration of (10-50) mg/ml of gallic acid was prepared in methanol. Concentration of 1mg/ml of plant extract was prepared in methanol and from that 0.5ml of sample was introduced into test tubes and mixed with 2 ml of Folin- Ciocalteu reagent and 2ml of 10% of sodium carbonate solution. The tube was covered and allowed to stand for 30 min at room temperature before the absorbance was measured at 760 nm spectrometrically. The Folin- Ciocalteu reagent is sensitive to reducing compounds including polyphenols, thereby producing a blue colour upon reaction. This blue colour is measured spectrophotometrically. Accordingly, total phenolic content was determined [23].

Antioxidant activity of the plant extract

The ability of plant extracts to scavenge hydrogen peroxide can be estimated according to the peroxide method. A solution of hydrogen peroxide (40 mM) is prepared in phosphate buffer (50 mM pH 7.4). The absorbance of hydrogen peroxide is determined by absorption at 230 nm using a spectrophotometer. Extract (100µg/mL) in distilled water is added to hydrogen peroxide and absorbance at 230 nm is determined after 10 min against a blank solution



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containing phosphate buffer without hydrogen peroxide. The percentage of hydrogen peroxide scavenging is calculated as follows:

$$\% \text{ scavenged (H}_2\text{O}_2) = (A_0 - A_1)/A_0 \times 100$$

Where A_0 is the absorbance of the control and A_1 the absorbance of the sample [24].

Antimicrobial assessment**Broth dilution method**

The minimum inhibitory concentration (MIC) was determined using the broth dilution method as described by a specific method [25]. Concentrations of extracts (1-9 mg mL⁻¹) dilutions were prepared using tubes containing 9 ml of double strength broth. In all test tubes, test antimicrobial compound is added except uninoculated (negative control) and control (positive) tube. The positive control tube is to check for the suitability of the test microorganism and the viability of the inoculums. The final volume was adjusted in all tubes by using sterile water. The tubes were inoculated with the suspension of standardized inocula (0.5 McFarland standard) and incubated at 37°C for 24 h. MIC was recorded as the lowest concentration of extract showing no visible bacterial growth.

Disc diffusion method

The disc diffusion assay was used to screen for antibacterial activity as described by the scientists [26]. The standard inoculum was introduced onto the surface of the sterile agar plates and a sterile glass spreader was used for even distribution over the media. Blank sterile paper discs (6 mm) were placed on the inoculated Mueller-Hinton agar surface and impregnated with 50 µL of the different extracts. A concentration of 10 µg/disc of Streptomycin (Sigma Aldrich, India), was used as a standard. The procedure was repeated for all the selected bacterial species used. The plates were incubated at 37°C for 24 h. All tests were performed in triplicate and the antibacterial activity was expressed as the mean diameter of inhibition zones (mm) produced by the extracts.

In-silico study

Molecular docking method has been used to identify the phytochemical from the plant extract that act as a ligand and form a strong covalent bond with the microbial protein to successfully inhibit the microbe. The discovery studio module of the biovia software is using for identify molecular interaction and perform molecular docking. In this process, first the pdb files for the phytochemicals (Kaempferol) found in the *Sauropus androgynous* plant were downloaded from the website drug bank. The protein DNA helicase Crystal structure of the N-terminal domain of Staphylococcus aureus single-stranded DNA-binding protein forms complex with a small molecule inhibitor data base code (5XGT) was collected from RCSB protein data bank. Molecular docking was done using the HDock Server. The enzyme molecule was treated as the receptor molecule and the phytochemical was treated as the ligand. The high positive value of those indicators presented a good interaction between the ligand and the receptor. Thus, the interaction with high values might indicate the major phytochemical responsible for curing the disease. Kaempferol inhibit the activity of *S. aureus* by blocking the potential effect of DNA helicase Crystal structure of the N-terminal domain of Staphylococcus aureus single-stranded DNA-binding protein [27].

Method of formulation of herbal extract gel

The required amount of gelling agent was accurately measured and dispersed in a small amount of water with continuous stirring to produce a uniform dispersion. Then the drug was dissolved in a suitable solvent here using propylene glycol and added to the above dispersion. Other substances such as methyl paraben and propyl paraben were also added with continuous stirring. The final weight of the gel formulation was adjusted to 10 g with distilled water. The gel was stored in container with wide mouth.

Evaluation of gel formulation**Physical Characterizations**

The composition of gel using different gelling agents tested for colour, odour, homogeneity, in which the gels were placed in containers.





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Measurement of Surface pH

The pH formation of gel was measured using a digital pH meter. 1 g of gel was dissolved in 25 ml of distilled water in a beaker. The electrode was then immersed in the beaker solution and allowed to simmer for 1 minute and further reading was observed.

Spreadability

Indicates the level of area where the gel spreads easily when applied to the affected skin. The therapeutic potential of the gel also depends on its spreading value. It is periodically displayed in seconds taken by two slides to move from the gel placed between the slides under the direction of a specific load (20 g).

The formula for calculating gel spreadability is: $S = M * (L / T)$

Where,

M = Weight tied to the top slide (20 g)

L = Length of the glass slide slipped

T = Time taken to split the slides.

Tube Extrudability

In this experiment was taken a closed folding tube containing the composition of the ciprofloxacin gel. The gel was pressed tight at the end and a clamp was placed at the end of the tube to prevent any loosening. A weight of 500 g was placed on tube and removed from the cap. The gel was pulled out.

The formula for calculating tube extrudability is: $E = (M / A)$

Where,

E = Tube extrudability

M = Weight applied on tube (500 g)

A = Extrude gel area [28].

RESULTS AND DISCUSSIONS

Phytochemical Screening

D= Dragandroff's reagent M= Mayer's reagent

H= Hager's reagent W= Wagner's reagent

(+) signify positive result

(-) signify negative result

The result showed that the chloroform extract has primarily flavonoids and phenolic part which is generally important for antibacterial and antioxidant activity. *Ocimum tenuiflorum* was used as positive control to find out the validity of the reagent used for phytochemical screening.

Quantitative estimation of phenolic content

The absorbance value of the plant material is 0.852

Now by plotting the value on the equation the conc. was found out to be is 77.45 ug/ml.

Antioxidant assessment

Percent Scavenged; % (H₂O₂) = $[(A_0 - A_1) / A_0 \times 100]$

A₀ = absorbance of Control = 0.518

A₁ = the absorbance of plant sample = 0.36.

$0.518 - 0.36 / 0.518 = 0.3050 \times 100 = 30.50\%$.

Antibacterial Assessment

Note: The control disc used for solvent had no zone of inhibition, so there data was omitted from the above data. Inhibition zones including the diameter of the paper disc (6 mm). Results are expressed as the mean ± SEM of triplicate measurements. The MIC of chloroform extract of *Sauropus androgynous* were 5 mg/ml and 4 mg/ml against *S. aureus* and *E. coli*. 6 mg/ml and 4 mg/ml against *B. subtilis* and *P. aerogenosa*. The MIC determination was



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performed in triplicate for each organism. The chloroform extract exhibited (Table 4) potent anti-bacterial activity against *S. aureus* (12.12 ± 0.43 mm), *B. subtilis* (11.15 ± 0.30 mm), *E. coli* (10.33 ± 0.36 mm) and *P. aeruginosa* (12.50 ± 0.33 mm). The same for the standard drug was found to be 9 ± 0.12 mm, 10 ± 0.13 mm, 10 ± 0.21 mm and 10 ± 0.23 mm against *S. aureus*, *B. subtilis*, *E. coli* and *P. aeruginosa* respectively. The chloroform extracts of *Sauropus androgynous* was produced antibacterial activity against all the tested organisms i.e. gram negative bacteria (*E. coli* and *P. aeruginosa*) and gram positive bacteria (*S. aureus* and *B. subtilis*).

In-silico Study

Binding site shows that the ligand molecule (golden yellow lines) bind with the THR93 and VAL 92 amino acid fragments of the 5XGT receptor surface.

Expected Confidence score- 0.5-0.7. Table 6: In silico assessment. These are docking score of 10 modules involving docking of ligand and receptor. Module 1 shows the least value so it could be judge as the best fit.

Evaluation of gel formulation

Physical characterizations

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CONCLUSION

The results of this study indicate that the chosen plant entity's chloroform extract has a considerable amount of antibacterial activity against two separate pathogenic species. Additionally, the plant extract exhibits spectrophotometrically determined antioxidant activity, which may result in the scavenging of free radical forms inside biological systems. It has been determined that the total phenolic content may affect the antioxidant and antibacterial properties. An investigation has been conducted for a particular pathogenic bacteria enzyme whose activity may be inhibited by known phytoconstituents that have antibacterial properties. Formulations for herbal extracts have been created after careful consideration of their physicochemical properties.

In the future, if the protein or enzyme structure of the pathogenic entity, responsible for the various types of diseases, is known, the herbal formulation can be tested for the antibacterial activity and further In silico study can be done with different phytoconstituents responsible for the different activities.

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Table 1: Composition of Gel Formulation

INGREDIENTS	FORMULATION (g)
Plant extract (dry)	1
Hydroxy propyl methyl cellulose	1
Propylene glycol	2 ml
Methyl paraben	0.1
Propyl paraben	0.2
Distilled water	upto 10

Table 2: Phytochemical Screening

Plant Name	Terpenoids	Alkaloids				Glycoside	Flavonoids	Steroids	Phenolic content
		D	H	M	W				
<i>Putranjiva roxburghii</i>	-	+	-	-	-	-	+	-	+
<i>Ocimum tenuiflorum</i>	+	+	-	-	+	+	+	+	+

Table 3: Uv-Spectroscopic analysis of gallic acid

Conc. of gallic acid(ug/ml)	Observed Absorbance
10	0.077
20	0.186
30	0.271
40	0.430
50	0.611

Table 4: Assessment of Antibacterial activity of the plant extract

Microorganisms	Diameter of inhibition zone (mm)		MIC (mg/ml)
	Chloroform extract	Streptomycin	Chloroform extract
<i>S. aureus</i>	12.12 ± 0.43	9 ± 0.12	5
<i>B. subtilis</i>	11.15 ± 0.30	10 ± 0.13	6
<i>E. coli</i>	10.33 ± 0.36	10 ± 0.21	4
<i>P. aeruginosa</i>	12.50 ± 0.33	10 ± 0.23	4

Table 5: In silico study of the phytoconstituents

Plant name	Reported isolated compound (Ligand)	Activity	Microorganisms	Protein/Receptor name	Protein/Receptor specifications
<i>Sauropus androgynous</i>	Kaempferol (Flavonoids)	Antibacterial	<i>S. aureus</i>	DNA helicase	Crystal structure of the N-terminal domain of Staphylococcus aureus single-stranded DNA-binding protein (5XGT)





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Table 6: In silico assessment

Summary of the Top 10 Models										
Rank	1	2	3	4	5	6	7	8	9	10
Docking Score	-143.03	-140.89	-139.73	-138.41	-137.79	-137.57	-137.36	-137.01	-136.70	-136.40
Confidence Score	0.4652	0.4546	0.4488	0.4423	0.4393	0.4382	0.4371	0.4354	0.4339	0.4324
Ligand rmsd (Å)	50.17	49.16	45.01	40.82	51.30	34.43	51.04	56.33	43.11	49.22
Interface residues	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9	model 10

Table 7: Physical Characterizations of Gel formulation: Physical characterizations

FORMULATION	COLOUR	ODOUR	HOMOGENECITY
F1	Yellowish white	Pleasant	Homogenous

Table 7: Surface pH of Gel formulation: Measurement of surface pH

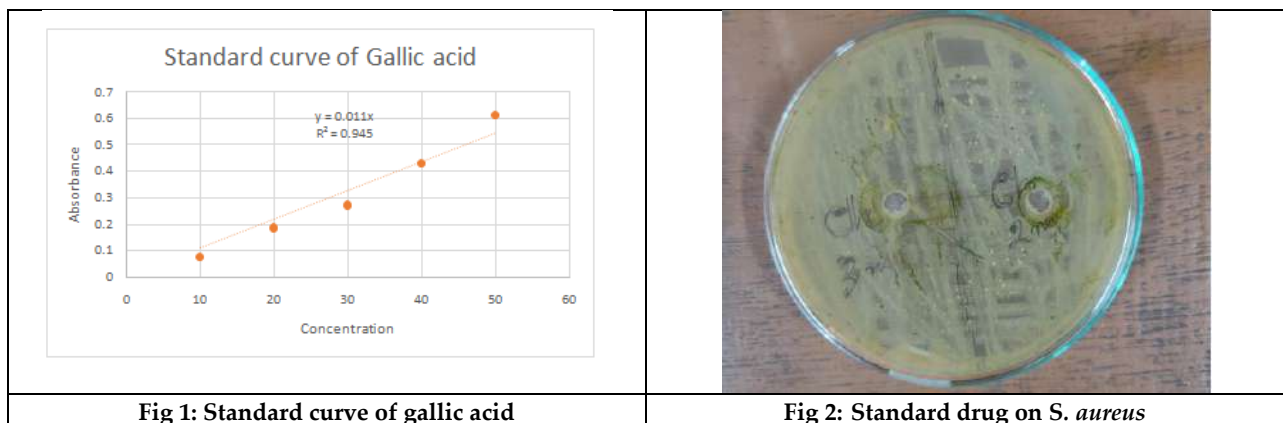
FORMULATION	SURFACE pH
F1	6.2

Table 8: Spreadability of Gel formulation: Spreadability

FORMULATION	SPREADIBILITY (g.cm/sec)
F1	12.5

Table 9: Tube Extrudability of Gel formulation: Tube extrudability

FORMULATION	TUBE EXTRUDABILITY (g/cm ²)
F1	78





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Fig 3: Standard drug on *P. aeruginosa*



Fig 4: Plant extract on *S. aureus*



Fig 5: Plant extract on *P. aeruginosa*



Fig 6: Standard drug on *B. subtilis*



Fig 7: Standard drug on *E.coli*



Fig 8: Plant extract on *B. subtilis*





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Fig 9: Plant extract on *E. coli*

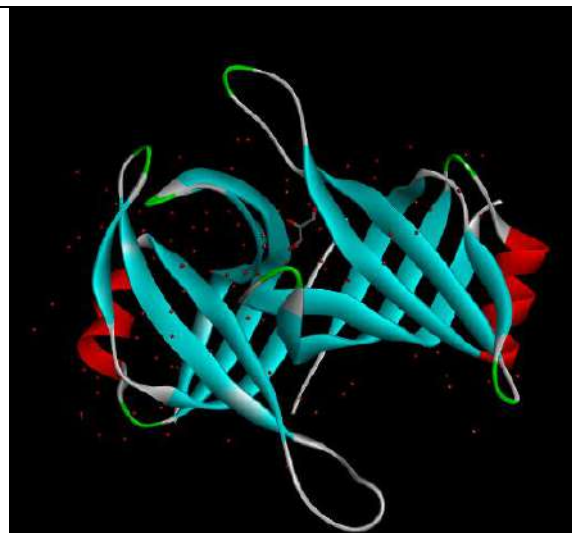


Fig 10: Protein structure of binding site of data base code (5XGT)

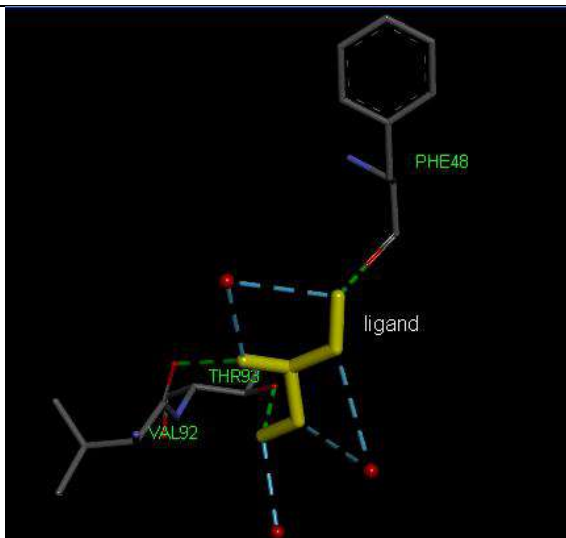


Fig 11: 3D Binding site of ligand in enzyme structure

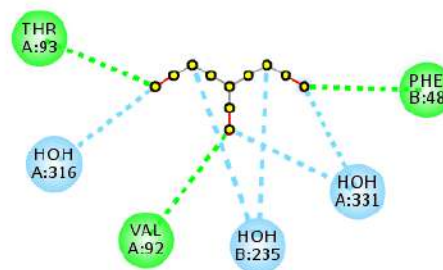


Fig 12: 2D Binding site of ligand in enzyme structure





The Growing Scope of Telerehabilitation in Spinal Cord Injury: A Feasibility Trial

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ABSTRACT

SPINAL CORD INJURY (SCI) is a terrible and debilitating condition that affects all regions of the world. In India, around 1.5 million individuals live with SCI. In low- and middle-income countries patients who sustain spinal cord injuries are more likely to have major consequences after being discharged from the hospital. Telerehabilitation emerged as a means of addressing the unmet requirements of persons with SCI. The study aimed to evaluate the effectiveness of telerehabilitation in spinal cord injury patients, to improve the functional status of a person, and to provide psychological support to the patient. A feasibility trial was conducted in the e-OPD of the College of Physiotherapy in PGIMS Rohtak. 480 patients were recruited from 2021-23. The discharged patients having spinal cord injuries who were admitted to the Paraplegic unit and other orthopedic units of PGIMS Rohtak were taken for the study. The patients were provided with telerehabilitation services at their convenient locations. The common age group of patients was 17- 40 years of age. 125, 143, and 178 SCI cases were recorded with telerehabilitation services for years 2021, 2022 and 2023 respectively. SCI patients were either bedridden or wheelchair-bound or use assisted or orthosis-dependent ambulation. For those patients, telerehabilitation had opened the doors for hope and possibilities as a feasible intervention.

Keywords: Spinal cord injury, telerehabilitation services, Institution-based rehabilitation



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INTRODUCTION

Most of the cases of spinal cord injury (SCI) can be divided into two types complete spinal cord injury and incomplete spinal cord injury Complete spinal cord causes permanent damage to the area of the spinal cord. Paraplegia or tetraplegia are result of complete spinal cord injury.[1]SCI is a severe disorder that impacts every part of the world.[2]Compared to their contemporaries without impairment, people with SCI are two to five times more likely to pass away too soon and have worse general health.3 An estimated 10.4 to 83 cases of SCI per million people worldwide are reported each year, with a majority of males.[4]In India, around 1.5 million individuals live with SCI. Every year, over 20,000 new cases of SCI are reported. Most of them are males between the ages of 16 and 30, indicating a greater occurrence among the young, energetic, and economic segment of society.[5] In low- and middle-income countries, patients who sustain spinal cord injuries are more likely to have major consequences after being discharged from the hospital. Common complications include pressure ulcers, respiratory and urinary tract infections, depression, fecal and urine incontinence, and autonomic dysreflexia. These consequences may be life-threatening.[6]Cardiovascular disease is one of the primary cause of early mortality in patients with spinal cord injuries. Exercise and physical activity may help persons with spinal cord injuries maintain or enhance their muscular strength and flexibility as well as decrease pain and the chance of developing cardiovascular disease[7].

Medical issues such as loss of mobility, autonomy, bowel and bladder function, and neuropathic pain, as well as social concerns such as strained spouse relationships and poor social adjustments all contributed to a reduced quality of life. To reduce the probability of poor QoL following SCI, these issues might be addressed by a more complete rehabilitation program[8]. Telerehabilitation emerged as a means of addressing the unfilled requirements of persons with SCI. Individuals with SCI have used telerehabilitation to obtain remote consultations, guidance with exercises and therapy, and even access educational materials suited to their requirements. When the COVID-19 pandemic was at its worst and in-person visits were restricted, the advantages of telerehabilitation for those with SCI became even more evident. Telerehabilitation provided ease and flexibility by eliminating the need for extensive travel and enabling patients to receive treatment from the comfort of their homes. Telerehabilitation also preserved patient and healthcare professional safety by reducing the risk of virus transmission.[9] The present study aims to evaluate the effectiveness of telerehabilitation in spinal cord injury patients, to improve the functional status of a person, to provide psychological support to the patient, and to provide time-to-time guidance for bed-related complications and management of pressure sores.

MATERIAL AND METHODS

A feasibility trial was conducted in the E-OPD of the College of Physiotherapy in PGIMS Rohtak. 480 patients were recruited from 2021-23. The discharged patients having spinal cord injuries who were admitted to the Paraplegic unit and other orthopedic units of PGIMS Rohtak were subjects of taken under the study. The patients were provided with telerehabilitation services at their convenient locations. The patient's and their caregiver's burden was assessed by structured telephonically conversation every month. Patient chief complaints were discussed and were asked about regular inspection of skin. Individualized exercises suitable for people with SCI were filmed and shared individually with participants through WhatsApp and a general physiotherapy advice template was also shared along with patient education. For passive SCI patients' education and exercise programs were made to understand their respective caregivers. Diaries were reviewed remotely by the physiotherapist who contacted patients by phone every 2 weeks. The progress was discussed and updates to exercise programs were made, as appropriate, by adding/removing exercises or changing the difficulty or number of repetitions/sets. A Type of a telephone conversation shared by patients is presented in Table 1.



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RESULT

The common age group of patients was 17- 40 years of age. 125, 164, and 178 reported SCI cases were provided with telerehabilitation services for years 2021,2022 and 2023 respectively as shown in Figure 3. The patients were assessed twice weekly initially and then periodic sections every 2 months and then follow-ups after 6 months were conducted. After that ,the patients were allowed to contact as per their needs. The periodic telephonic conversations resulted in self-reported improvement in quality of life and enhanced confidence among patients. One of the such conversation was as follows:”

मुझे पीजीआई –ओपीडीके द्वारा आने वाली कालसे काफी फायदा होरहा है और मैं इस सुविधासे काफी जुड़ा हु आमहसूसकरता हूं मुझे अपनी समस्या के समाधानके लिए पीजीआई आनानही पड़ता जोकि इस महामारीके दौरमें बहुत मुश्किल है”.

The patients have reported that these periodic calls have alleviated their sense of social isolation, improved satisfaction, and assisted them in remembering techniques for SCI management. These periodic calls not only help patients but also help the caregivers of SCI patients. Caregivers have a degree of perceived burden that is closely linked to the increased need for psychological support and lack of social conditioning and mental and physical health.

DISCUSSION

This study reveals that telerehabilitation is a feasible and effective approach for providing exercise to patients with SCI. The follow-up talk indicated that the videos were simple to use, engaging to watch, beneficial for health and well-being, and cost-effective for SCI patients during the COVID-19 pandemic. Telerehabilitation is an increasingly popular method of expanding access to care in low- and middle-income countries, particularly where care delivery is difficult or in remote geographical places. Telerehabilitation includes utilizing information and communication technology to offer rehabilitation services and patient education. People with SCI confront additional challenges than able-bodied people. During the pandemic, telerehabilitation began to thrive to properly provide health care. It served as a safe, viable, and cost-effective approach to treating individuals with spinal cord injury. The method is useful for providing care in low- and middle-income nations where healthcare delivery is difficult. The most commonly related conditions observed in SCI patients were bladder and bowel issues, pain spasticity, and pressure sore injuries. For pressure sore injuries and general mobility of bed-ridden patients, the transfer training included education and training was accompanied by videos. Straater et al. (2014) and Sechrist et al. (2018) also found that video telerehabilitation was an effective and convenient way to discuss bowel and bladder concerns, as well as alleviate pressure sores and chronic pain issues. Furthermore, video telerehabilitation demonstrated a potential benefit to caregivers of SCI patients throughout the transition from acute rehabilitation to home.[10,11] However, some of the major challenges faced while providing telerehabilitation services were a lack of acceptance and a skeptical approach. Similar concerns were described by Mandriola et al. in (2019), and Leochio et al. in (2020). Patients were concerned about sluggish internet speeds and other technological difficulties. [12,13,14] In our study, these difficulties were resolved via phone calls and text messages. Other challenges experienced were a lack of awareness for which patients and caregivers were first given counselling and assurance through long telephonic conversations and a lack of manpower to regulate technical issues and provide a wide network for telerehabilitation services. Taking into consideration, the effectiveness of telerehabilitation services, there are several ongoing efforts by the government to expand the use of telerehabilitation; still, there is a long way to go.

Limitations

The current study was only a feasibility trial so it is difficult to evaluate the true intervention effects and quantify the outcome measures.



**Bhawna Verma et al.,****Future research**

The present study may be replicated using a controlled trial design. SCI-tailored and personalized programs with sufficient outcome measures evaluating quality of life and other parameters should be incorporated.

CONCLUSION

This was a feasibility trial conducted to report the benefits and challenges faced by physical therapists, patients, and caregivers as it is the first study to be conducted in the College of Physiotherapy, E-OPD PGIMS Rohtak regarding the effectiveness of telerehabilitation services provided to Spinal cord injury patients. SCI patients were either bedridden or wheelchair-bound or use assisted or orthosis-dependent ambulation. For those patients, telerehabilitation had opened the doors for hope and possibilities as a feasible intervention. However, it is recommended that specific interventions with proper follow-ups should be implemented by the future potential researcher.

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Table 1: A structured telephonic conversation was made to assess the SCI patient

रोगी से संबंधित प्रश्न			
पिछले महीने के दौरान			
क्या आपको कठिनाई हुई है			
• अपना ख्याल रखना जैसे खाना, ड्रेसिंग या स्नान करना	हाँ	नहीं	
• बिस्तर से अंदर या बाहर जाना	हाँ	नहीं	
• घर के अंदर चलना, जैसे कि आपके घर के आसपास	हाँ	नहीं	
• पिछले महीने के दौरान			
• आप एक खुश व्यक्ति है	हाँ	नहीं	
• क्या आप नर्वस व्यक्ति रहे हैं	हाँ	नहीं	
• क्या आप खुद से धुँधल करते हैं	हाँ	नहीं	
• क्या आप उँध में इतना नीचे महसूस करते हैं कि कुछ भी आपको खुश नहीं कर सकता है	हाँ	नहीं	
• पिछले महीने के दौरान आप	हाँ	नहीं	
• अपने आस-पास के लोगों से खुद को अलग कर लिया	हाँ	नहीं	
• अन्य के प्रति स्नेह प्रभावित	हाँ	नहीं	
पिछले महीने के दौरान			
• पिछले महीने के दौरान आप			
क्या आपको मूल मूत्र विसर्जन के प्रबंध में सहायता की आवश्यकता पड़ी है	हाँ	नहीं	
• क्या आप को अपने मूल मूत्र विसर्जन घर पूरा कंट्रोल है	हाँ	नहीं	
Caregiver के लिए सवाल			
यारीरिक बोझ संबंधित सवाल			
• क्या आपको पीठ में दर्द रहता है ?	हाँ	नहीं	
• क्या आप बिगड़ मरुचुस करते हैं ?	हाँ	नहीं	
• क्या आप काम और परिवार के प्रति जिम्मेदारी के बीच तनाव महसूस करते हैं ?	हाँ	नहीं	
• क्या आप सोयनीयता की स्थिति और व्यक्तिगत समय की स्थिति महसूस करते हैं ?	हाँ	नहीं	
• क्या रिश्ते की बेसुभाव की वजह से आपको नींद खराब हो गई थी ?	हाँ	नहीं	
• क्या मरीज की बेसुभाव की वजह से आपके संबंध दूसरे परिवार के लोगों, रिश्तेदारों और दोस्तों के प्रभावित रहे हैं ?	हाँ	नहीं	
• क्या आपको लगता है कि आपका रिश्तेदार उसकी जरूरत से ज्यादा मदद मँगता है ?	हाँ	नहीं	
• क्या आपको लगता है कि आप अपने रिश्तेदार की संवे समय तक बेसुभाव नहीं कर पाएंगे ?	हाँ	नहीं	
आर्थिक बोझ से संबंधित प्रश्न			
• क्या वर्तमान में आप कार्यरत हैं	हाँ	नहीं	
• क्या आपने अपने रिश्तेदारों की स्थिति के कारण अपने काम के घंटे कम कर दिए हैं	हाँ	नहीं	
• जब आप काम कर रहे थे तो आपके रिश्तेदारों की बीमारी या स्थिति ने आपके काम आत्मकी उत्पादकता को प्रभावित किया	हाँ	नहीं	
• क्या आपने अपने रिश्तेदार की स्थिति के कारण काम करना बंद कर दिया	हाँ	नहीं	
• क्या आपके पास अपनी जरूरतों को पूरा करने के लिए पर्याप्त पैसा है	हाँ	नहीं	

Table 2 Typically presents an overview of general physiotherapy advice given to SCI patients.

General Physiotherapy Advice	
• PROM or AROM exercises of upper limb and lower limb as per patient’s condition	
• Advice for maintaining proper bronchial hygiene	
• Advice for bowel and bladder care	
• Proper Positioning and Bed care	
• Strengthening exercises if patient has weakness	





• Psychologicalcounseling



Figures 1. Depicts photos sent by a caregiver for skin inspection



Figure 2: Illustrates the training for turning provided to caregiver through videos for bed ridden SCI patients.

Figure 3: Graphical representation of the SCI patients given Telerehabilitation showing increased services over the years.





Mathematical Fuzzy Modelling for the Secretion of Cortisol Due to Human Stress based on Symmetric Trapezoidal Fuzzy Numbers

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ABSTRACT

The aim of this work is to present a novel mathematical fuzzy model for the secretion of cortisol in response to human stress. The model is based on the use of closest symmetric trapezoidal fuzzy numbers. Frequency distribution is used to partition intervals of varying lengths. By converting trapezoidal fuzzy numbers into the closest symmetric trapezoidal fuzzy numbers, we provide a case study on classification with severely unbalanced data sets. Linguistic fuzzy rule-based systems have been shown to exhibit superior performance compared to other strategies in this scenario. The novelty of this work is to develop a mathematical fuzzy model to analyze cortisol secretion, resulting in human stress, using symmetric trapezoidal fuzzy numbers. And applied through a fuzzy rule-based system with unbalanced data sets to study the secretion of cortisol due to human stress on symmetric trapezoidal fuzzy numbers.

Keywords: Cortisol, Surgery, F-transform

2000 Mathematics Subject Classification: Primary 90B22 Secondary 90B05; 60K30





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INTRODUCTION

Empirical evidence consistently demonstrates that fuzzy logic surpasses traditional mathematical and statistical modelling methods in several applications that include the representation of real-world data [2]. We are engaged in the examination of the Direct Set Assignment (DSA) extrapolative forecasting technique. The DSA technique is a non-linear extrapolative forecasting approach that was created using the Mamdani Development Framework. It is aimed to imitate the structure of a fuzzy logic control system [3] [4]. Research aimed at enhancing the precision of extrapolative techniques should prioritize the creation of statistically straightforward approaches that possess the quality of being resilient to the variations present in real-world data caused by both random and non-random occurrences.

Elective surgery is a significant cause of stress for the patient [11], [12]. Several endeavors have been undertaken to adequately prepare patients before to surgery in order to diminish stress and enhance the final result. Medical research has determined that our video preparation effectively reduces anxiety and stress, as evidenced by a decrease in systolic blood pressure during surgery and a decrease in cortisol excretion. Additionally, it has been found to reduce the need for pain medication after hip replacement surgery. The assessment of preoperative locus of control yielded contrasting findings. A study by [10] highlighted that in the context of surgical intervention, the capacity to relinquish control may be more advantageous than a controlling approach. The F-transform of function f is a vector that consists of weighted local mean values of f as its components. The first stage in defining the F-transform of $f: X \rightarrow \mathbb{R}$ involves choosing a fuzzy partition of the universal set X using a finite collection of fundamental functions.

$$A_1(x) \geq 0, \dots, A_n(x) \geq 0 \quad (1)$$

which are continuous and satisfy the condition $\sum_{i=1}^n A_i(x) = 1$.

METHODOLOGY

Fuzzy transform

Basic functions of respective fuzzy sets are often referred to as basic functions, or alternatively, granules, information chunks, etc. Their selection demonstrates the kind of ambiguity that is associated with the understanding of x . After selecting the fundamental operations, we proceed to define the F-transform of a continuous function $f: X \rightarrow \mathbb{R}$ as a vector (F_1, \dots, F_n) , where

$$F_i = \left(\int f(x) \cdot A_i(x) dx \right) / \left(\int A_i(x) dx \right) \quad (2)$$

F-transform «satisfies the following properties:

(i) $y = F_i$ minimizes $\int_a^b (f(x) - y)^2 A_i(x) dx$

(ii) for a twice continuously differentiable function f , $F_i = f(x_i) + O(h_i^2)$, where h_i is the length of the support of A_i .

The F-transform is used in applications as a skeletal representation. This model generates a compressed representation of an image when f is an image [7], extracts trend values when f is a time series [8], and produces a numeric model when f is utilized in numeric calculations such as integration or differentiation [9]. Once we have determined the components F_i of the F-transform, we may (roughly) restore the original function f as $\bar{f}(x) =$

$$\sum_{i=1}^n F_i A_i(x) \quad (3)$$

The formula (3) is referred to as the F-transform inversion formula in reference [1]. The formula (3) denotes a continuous function that provides an approximation of f . Under certain acceptable assumptions, a series of functions denoted by (3) converges uniformly to f .





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EXAMPLE

A total of one hundred patients were included in the trial after the provision of written informed permission. The inclusion criteria for the study were individuals aged 18 years or older, diagnosed with osteoarthritis of the hip joint, and without a history of previous hip replacement surgery. Anxiety and pain levels were assessed daily for a period of 5 days, starting from the day before the surgery. Additionally, the use of painkillers and sedatives after the surgery was documented. Cortisol levels in urine were measured in 12-hour samples obtained throughout the night for 5 consecutive nights, starting from the night before the surgery. The preparation group consisted of 46 randomly assigned patients, whereas the control group consisted of 54 patients. Following the surgery, the average levels of state anxiety dropped in both groups. However, the preparation group maintained lower levels of anxiety throughout the four days after the procedure. The pain rating on the visual analog scales shown an increase from the preoperative day to the morning before to surgery, and then demonstrated a reduction on a daily basis after the operation.

Let us give an example of the F-transform of

$f_1(x) = \frac{2}{2+x}$ and $f_2(x) = \frac{2}{1+x}$ «with respect A_1, \dots, A_4 . For simplicity, we assume that basic functions A_1, \dots, A_4

are of trapezoidal shape and constitute a uniform partition of $[0,8]$. Their analytical representation is as follows:

$$\begin{aligned}
 A_1(x) &= \begin{cases} 0, & \text{otherwise} \\ 1, & x \in [1,2] \\ 3-x, & x \in [2,3] \end{cases} &
 A_2(x) &= \begin{cases} x-2, & x \in [2,3] \\ 1, & x \in [3,4] \\ 5-x, & x \in [4,5] \\ 0, & \text{otherwise} \end{cases} & (4) \\
 A_3(x) &= \begin{cases} x-4, & x \in [4,5] \\ 1, & x \in [5,6] \\ 7-x, & x \in [6,7] \\ 0, & \text{otherwise} \end{cases} &
 A_4(x) &= \begin{cases} x-6, & x \in [6,7] \\ 1, & x \in [7,8] \\ 0, & \text{otherwise} \end{cases}
 \end{aligned}$$

Corresponding Fuzzy function for above figure 1.

The original motivation for F-transform came from fuzzy modeling. For example, in the situation corresponding to the inverse F-transform, we have n rules

$$\begin{aligned}
 &\text{If } x \text{ is } A_1 \text{ then } y = F_1, \\
 &\text{If } x \text{ is } A_n \text{ then } y = F_n
 \end{aligned} \tag{5}$$

These rules are Takagi-Sugeno (TSK) rules with singleton (constant) right-hand sides. For TSK rules, the value corresponding to a given input x is $\bar{f}(x) = \sum_{i=1}^n F_i A_i(x) / \sum_{i=1}^n A_i(x)$. Since $\sum_{i=1}^n A_i(x) = 1$, we get formula (3).

Figure2 provides a «graphical representation of the basic functions A_1, \dots, A_4 , of the function $f_1(x)$ and $f_2(x)$ of its F-transform components F_1, \dots, F_4 , and of the inverse F-transform. By (2) the values of the components F_1, \dots, F_4 of the F-transform.

RESULTS AND DISCUSSION

The Known Probabilistic Interpretation of Fuzzy Modeling Leads to a Probabilistic Interpretation of F-Transform.

This work demonstrates that by modifying the probabilistic interpretation presented in reference [5], we are able to provide a justification for the formulae of F-transform without requiring any extra assumptions about the probability distributions. Mathematically, this adjustment involves using Bayes formulae and assuming prior distributions, which serve as a means to explain previous knowledge in statistics, rather of assuming the actual distributions. Therefore, we have a more inherent probabilistic explanation of the F-transform. More precisely



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- (i) The paper [5] demonstrates that there is a logical interpretation of the F-transform formulas that is based on probability and is reasonable.
- (ii) However, this interpretation allows for the possibility that there are other equally reasonable assumptions about the probability distributions that can result in different formulas.
- (iii) In our modified interpretation, we prove that the fundamental probabilistic framework definitively determines the F-transform formulas, without requiring any assumptions about the» probability distributions [6].

CONCLUSION

We provide a revision of a probabilistic interpretation outlined in reference [5]. In this alteration, the associated probabilistic model unequivocally yields the equations of the F-transform. An analogous alteration is delineated within a broader context of fuzzy modeling. The analysis revealed that the use of the videotape resulted in a reduction in worry and tension. This was determined by examining the levels of urine Cortisol excretion and the rise in intraoperative systolic blood pressure. These findings align well with the concepts of Fuzzy Transform and Fuzzy modeling.

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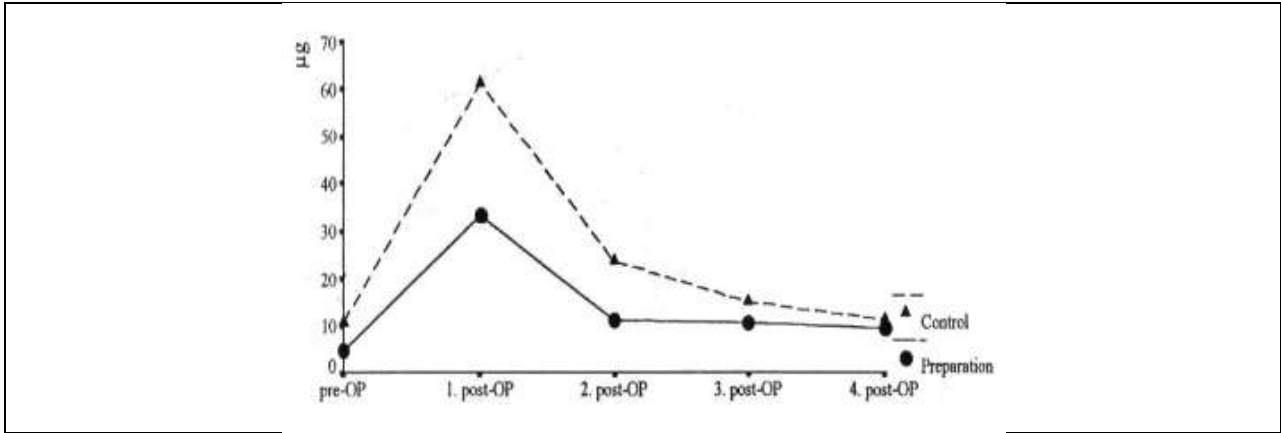


Figure 1 - Plots representing the pain rating on the visual analog scales

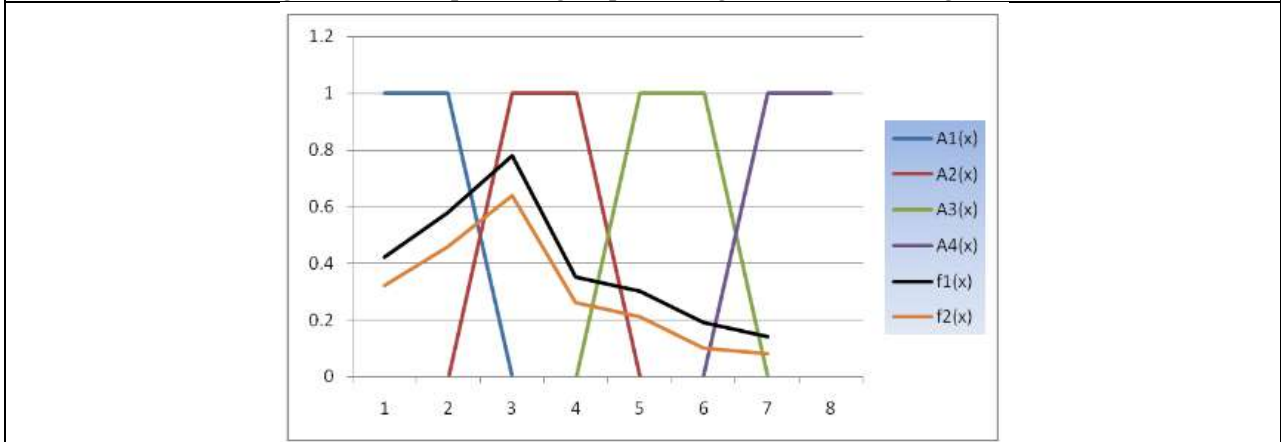


Figure 2 – Plots representing the graphical representation of F-transform





***Trichoderma* - its Role as Biocontrol and Growth Promotor Agent Incrop Production**

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ABSTRACT

Despite the slow adoption of biopesticides compared to chemicals, with only 2% of biopesticides currently available, there has been success in commercializing products based on various species of *Trichoderma* in India. These potential *Trichoderma* isolates are formulated using a variety of organic and inorganic carriers through either solid or liquid fermentation technologies. They are applied through methods such as seed treatment, bio-priming, seedling dip, soil application, and foliar spray. Formulations of *Trichoderma* with mixed strains have shown better performance than individual strains in managing pests and diseases of crop plants, as well as promoting plant growth. However, the commercialization of these bioproducts is primarily hindered by their poor shelf life. Therefore, research should focus on increasing the shelf life of these formulations by developing superior strains that support increased shelf life, or by standardizing organic formulations that offer maximum shelf life with minimal contaminants. Despite the limitations of these *Trichoderma* products, they can be addressed by enhancing biocontrol through environmental manipulation, accurate strain identification using molecular approaches, use of beneficial organism mixtures, physiological and genetic enhancement of biocontrol mechanisms, and manipulation of formulations. Presently, formulations with nano compounds are being used to reduce the application of conventional pesticides and fertilizers. Among the most commonly used are nanoparticles (NPs) of copper, zinc, or silver, which are known for their cytotoxicity. Their accumulation can alter the dynamics of microbes present in the soil. In agriculture, *Trichoderma* is extensively used as a safe biocontrol strategy and to boost plant yield. This makes it likely to come into contact with nanomaterials that can affect its viability as well as its biocontrol and plant growth





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promotion effects. This study summarizes the key findings regarding the interaction of Trichoderma and nanotechnology, including its use in synthesizing NPs and the potential impact of these compounds on this fungus and its associations.

Keywords: *Trichoderma*, Nanotechnology, Biopesticides, Organic, Inorganic.

INTRODUCTION

Traditional methods of managing plant diseases and improving yields, such as the use of chemical pesticides, herbicides, or fertilizers, are not environmentally friendly. These methods involve substances with various aromatic groups or methylated and ethylated compounds that have significant environmental impacts. Long-term use of chemical pesticides can contaminate water, pollute the atmosphere, and sometimes leave harmful residues that can lead to the development of resistant organisms. To address these issues, researchers are exploring alternative options, such as the use of biocontrol agents (BCAs) for disease control. These can be used either alone or in combination with other chemicals for eco-friendly and sustainable disease control methods. Currently, several BCAs have been identified and are available as bacterial agents, such as *Pseudomonas*, *Bacillus*, and *Agrobacterium*, and as fungal agents, such as *Aspergillus*, *Gliocladium*, *Trichoderma*, *Ampelomyces*, *Candida*, and *Coniothyrium*. The green revolution has led to intensified agriculture to meet the growing global demands for food and fiber. However, this has also damaged natural ecosystems by polluting groundwater and foodstuffs, and degrading the environment. Plant diseases are a major concern in global cultivation, resulting in the loss of billions of dollars of farm produce. There is an urgent need to manage diseases to ensure a steady and consistent supply of marketable produce for the growing world population. In disease management, the increased use of chemicals has negatively impacted environmental quality and led to the emergence of many organisms that are resistant to these chemicals.

Chemical pesticides, the most common means of shielding plants from diseases, have put tremendous strain on the agricultural environment in recent decades. Despite chemical plant protection products' high efficacy, questions remain regarding their safe usage, effects on the environment, and safety for humans and animals (Ghorbanpouret *al.*, 2018). The result of the abuse of chemical pesticides is an increase in the resistance of pathogens to pesticides, and the contamination of soil and ground waters. Furthermore, pesticides have a detrimental effect on non-target organisms (e.g., beneficial insects, including pollinators), soil microbiomes, and the general condition of terrestrial and aquatic ecosystems (Tilman *et al.*, 2002. Alizadeh *et al.*, 2020). To protect the environment from the negative effects of chemical fungicides, various actions and strategies of sustainable food production systems are taken, including Integrated Pest Management (IPM) and organic farming (Rahman *et al.*, 2018, Grasswitz 2019). Biological Control Agents (BCAs) are a tactic used to manage plant pathogen populations. These agents are derived from natural products and living microbes or their metabolites (Rahman *et al.*, 2018, Thambugalaet *al.*, 2020). In an attempt to commercialise non-pathogenic bacteria and fungi as BCAs, the majority of research has been done over the last few decades to assess their viability and efficacy (Subediet *al.*, 2020, Niu et *al.*, 2020). Many bacterial and fungal strains, such as *Pseudomonas* spp., *Bacillus* spp., *Streptomyces* spp., *Trichoderma* spp., *Glomus mosseae*, *Gliocladium virens*, *Pythium oligandrum*, and *Beauveria bassiana*, have been used as BCAs as a result of the conducted studies. These strains have been successful in controlling soil-borne diseases of valuable crops that are caused by fungi, oomycetes, bacteria, and nematodes (Savita 2019).

TRICHODERMA

Trichoderma, a genus of fungi that belongs to the Hypocreaceae family, is known to comprise over 100 species. Among the various species of Trichoderma, such as *T. viridae*, *T. haziarum*, *T. atroviridae*, and *T. asperellum*, only a few have been reported to be useful as biocontrol agents. Trichoderma is known to colonize the root surface or cortex and thrives best in the presence of abundant healthy roots. The fungus Trichoderma has a rich history, with its first report and description dating back to 1794. It was later suggested to be linked with the sexual state of a Hypocrea species.





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However, morphologically assigning the genus *Trichoderma*/*Hypocrea* proved to be challenging. It was even proposed that *Trichoderma viride* was the only species in the genus. The first steps towards developing a specific protocol for species identification were taken in 1969. For the past 70 years, *Trichoderma* spp. have been recognized for their ability to produce antibiotics that inhibit the growth of pathogenic organisms, leading to their use as a biocontrol agent. Over time, many new species of *Trichoderma* were discovered, and by 2013, the genus already consisted of more than 200 phylogenetically defined species based on rpb2 sequence.

Characteristics

Trichoderma, a genus of fungi, is commonly found in various soil types, where it is often the most abundant type of fungus that can be cultured. *Trichoderma* species are frequently isolated from both forest and agricultural soils, as well as from wood. Some species have even been discovered growing on other fungi. The *Trichoderma* genus is known to encompass approximately 90 species. This fungus typically thrives in a temperature range of 25–30 °C and does not grow at higher temperatures. The most conducive culture media for its growth are cornmeal dextrose agar, where the colonies appear transparent, and potato dextrose agar, where the colonies appear white. Some species may secrete a yellow pigment into the agar and produce a distinctive sweet or coconut-like odor. Under a microscope, the conidiophores are seen to be highly branched, either loosely or compactly tufted, often forming distinct concentric rings or borne along sparse aerial hyphae. The typical *Trichoderma* conidiophore with paired branches takes on a pyramidal shape. Most strains of *Trichoderma* do not have a sexual stage and produce only asexual spores. *Trichoderma* species that reproduce sexually are known as teleomorphs, and they belong to the ascomycete genus *Hypocrea*. The development of fleshy stromata in light or dark brown, yellow, or orange hues is what distinguishes them. The bicellular ascospores are frequently green in colour. To far, descriptions of around 200 species of *Hypocrea* have been made.

Morphology

Trichoderma spp. exhibits rapid growth, maturing within 3–5 days. Initially, the colony appears as fluffy white tufts, which later transition to a greenish color due to conidia production. The presence of concentric rings on the agar plate characterizes it. The colony's reverse side is whitish yellow or light tan, sometimes shifting to yellow or pale orange. Morphologically, this genus features branched conidiophores with coiled, straight, or undulate apices, along with the presence of phialides (Bisset, 1991). To identify the bioagent, cultural and morphological characteristics are compared with those described by Rifai (1969) for *Trichoderma viride*. Factors considered include growth rate, colony appearance, surface color, colony reverse, texture, conidiation, conidiophore branching, shape, and size. These observations were made on potato dextrose agar (PDA). The pure culture of *Trichoderma* was obtained using the single spore technique. Microscopic examination of culture slides confirmed it as *Trichoderma asperellum*, as documented by the Indian Type Culture Collection (ITCC) at the Division of Plant Pathology, Indian Agricultural Research Institute, New Delhi, India.

Ecology

Trichoderma species are widely distributed and commonly inhabit soil. They play a crucial role in cellulose degradation. Our study focused on the impact of temperature on the linear hyphal growth of *T. viride* under in vitro conditions. Initially, fungal growth was robust within the temperature range of 25–30°C, but beyond that, growth declined. The maximum average dry weight was observed at 30°C. pH also significantly influences fungal growth. The highest dry weight occurred at pH 7, followed by pH 6.5. Conversely, the lowest dry weight was recorded at pH 8.5. Regarding radial hyphal growth, purified *Trichoderma* performed best on potato dextrose agar (PDA), followed by malt agar, rose Bengal agar, and Sabouraud's agar. However, growth on Czapek's dox medium was suboptimal. Notably, previous research by Pandey and Upadhyay (1997b) highlighted that potato dextrose agar medium, prepared from fresh potatoes, was ideal for radial growth and sporulation of *T. viride*.





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Habitats and environmental condition

Trichoderma spp. are commonly found in various environments, including water, decaying wood, soil (especially around plant roots), and even non-natural materials like rubber foam or kerosene tanks. These fungi exhibit rapid growth and are prevalent in agricultural, prairie, forest, salt marsh, and desert soils across different climatic zones. While they are generally present in the litter of humid, mixed hardwood forests, they are more dominant in the H and F horizons. *Trichoderma* typically act as saprophytes, breaking down organic matter. However, they can also attack other fungi. Interestingly, their presence in soil emits a coconut-like odor, attributed to the volatile compound 6-pentyl-a-pyrone. Different species of *Trichoderma* thrive in specific temperature ranges: *T. viride* prefers cooler regions, while *Trichoderma harzianum* thrives in warmer climates. These preferences align with their optimal temperature requirements. Overall, *Trichoderma* spp. tend to be more abundant in acidic soils.

IDENTIFICATION OF TRICHODERMASPP

Morphological and cultural characteristic, and molecular identification of different species of *Trichoderma*, namely, *T. harzianum*, *T. asperellum*, *T. viride*, *T. atroviride*, *T. longibrachiatum*, *T. koningii*, and *T. virens* are described in the following section.

Morphological and cultural characteristic

Trichoderma harzianum

- Mycelium: Changes from watery white to light green in color. Reverse side of petri-plate shows uncolored ring-like zones.
- Colonies: Grow rapidly from 7 to 8 cm in diameter in 5 days, smooth surface, mycelial mat develop with white aerial hyphae.
- Conidiophores: Highly branched and forming loose tufts.
- Phialides: Short-skittle shaped, bulged at the middle, and narrower at the base, arise singly. Phialide size lies within a range of $7.2\text{--}11.2 \times 2.5\text{--}3.1 \mu\text{m}$.
- Phialospores: Sub globose or short ovoid often with truncate base, perfectly smooth walled, size ranging from $2.8\text{--}3.2 \times 2.5\text{--}2.9 \mu\text{m}$.
- Spore germination time: 12 h.

Trichoderma asperellum

- Mycelium: Forms a smooth hairy yellowish green cotton pattern usually in the form of 1–2 ringed Concentrics.
- Colonies: Changes cottony white to yellowish green and after 2 days from too deep chrysolite green, emitting coconut odor.
- Conidiophores: Arise highly branched in compact form and the phialides arise singly or in opposite pairs along the branches.
- Phialides: Appear in ninepin shape attenuated into long neck, usually $6.8\text{--}7.2 \times 3.0\text{--}3.4 \mu\text{m}$.
- Phialospores: Globose or short obovoid in shape, green colored with an approximate size of $3.6\text{--}4.0 \times 3.4\text{--}4.0 \mu\text{m}$.
- Spore germination time: 12–13 h.

Trichoderma viride

- Mycelium: Changes green to dark yellowish green after 2–3 days, no odor.
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- Colonies: Smooth surface, cottony white mycelial mat with aerial hyphae.
- Conidiophores: Conidia production is less in center than toward the margins with green conidia distributed throughout.
- Phialides: Long, swollen in middle, like slender, and horn shaped with a size range of $6.2\text{--}10.5 \times 3.1\text{--}3.9 \mu\text{m}$.
- Phialospores: Usually globose or obovoid often, perfectly smooth walled, with a size ranging from $2.6\text{--}3.0 \times 2.0\text{--}2.4 \mu\text{m}$.
- Spore germination time: 13 h.





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Trichodermaatroviride

- Mycelium: The mycelium mat appears watery white, submerged composed of translucent smooth and appear floccose on PDA.
- Colonies: The colony color changes after 2 days from yellowish green to artemisia green and reverse remaining dull yellowish and odorless.
- Conidiophores: Highly branched arise in compact form and the phialides solitary paired on the terminals, swollen at the middle and narrow at the tips.
- Phialides: Phialides appear in ampulliform and oblong shaped, curved, and constricted at the base, with a varying size of $5.2\text{--}10.5 \times 2.4\text{--}2.8 \mu\text{m}$.
- Phialospores: Globose in shape, green colored with an approximate size of $2.4\text{--}3.6 \mu\text{m}$.
- Spore germination time: 12–13 h.

Trichodermalongibrachiatum

- Mycelium: Mostly submerged translucent or watery white.
- Colonies: Changes after 2 days from yellowish green to lily green, no smell. Smooth conidiophores arise from substratum and form irregular tufts or arise from aerial hyphae.
- Conidiophores: Smooth conidiophores arise from substratum and form irregular tufts or arise from aerial hyphae.
- Phialides: Arises singly or in verticils of 2–3, usually lageniform, slightly constricted at the base, usually $3.4\text{--}5.2 \times 2.3\text{--}3.0 \mu\text{m}$.
- Phialospores: Smooth walled, obovoid to ellipsoidal, dilute green, apex broadly rounded, with an approximate size of $2.4\text{--}3.6 \mu\text{m}$.
- Spore germination time: 12–13 h.

Trichodermakoningii

- Mycelium: Creamy white changes from white to terreverte in color.
- Colonies: Crysty, compact, and glaucous like.
- Chlamydospores or conidiophores: Formed intercalary or terminally, much branched.
- Phialides: Narrow at the base, alternate to conical apices (Note: Most phialides of *T. koningii* arise singly and laterally and appears Nine-pin bowling shaped singly rather than pyramidal, size range of $3.8\text{--}7.6 \times 2.5\text{--}3.2 \mu\text{m}$).
- Phialospores: Ellipsoidal or oblonged, with a rounded apex and acute base, measuring $2.5\text{--}4.2 \times 1.8\text{--}2.6 \mu\text{m}$.
- Spore germination time: 14 h.

Trichodermavirens

- Mycelium: Changes watery white to nice green color with dull blackish green shades granules, no characteristic odor.
- Colonies: On potato dextrose agar medium, colonies grow rapidly from 7 to 8 cm in diameter in 5 days at 25°C temperature.
- Conidiophores: Branched irregularly near the apex with each branch terminated by a cluster of 3–6 closely bunched phialides.
- Phialides: Lageniform to ampulliform, swollen at the middle, attenuated to apex, broadly attached to the conidia in ranges between $4.4\text{--}12.8 \times 2.6\text{--}4.2 \mu\text{m}$ of size.
- Phialospores: Broadly ellipsoidal to obovoid, both ends rounded dark green in color and with a size range of $3.2\text{--}5.6 \times 2.5\text{--}3.9 \mu\text{m}$.
- Spore germination time: 13 h.

ENZYMES

Trichoderma, a saprophyte, is adapted to flourish in various environments and produces a broad spectrum of enzymes. Strains that produce specific enzymes can be selected and cultured in suspension to produce these enzymes in industrial quantities. For instance, with their adaptable metabolisms, Trichoderma and the closely related *Gliocladium* spp. can break down a wide variety of plant biomass, including polysaccharides like cellulose, chitin,



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inulin, laminaran, pectin, starch, and xylan, as well as oligosaccharides like melezitose, raffinose, and sucrose (Kubicek and Harman, 1998). Particular attention was given to *Trichoderma* spp. when it was discovered that strains isolated during World War II were especially effective in producing a complex of enzymes that attacked crystalline cellulose in very high yields. This realization largely came from the studies of E.T. Reese and M. Mandels at the US Army Laboratories (1939 to 1945), Natick, MA. A specific strain, *Trichoderma* sp. QM6a, later identified as *Trichoderma reesei* in honor of Elwyn Reese, produced up to 0.5% extracellular cellulase. In a bioenergy program, the production of ethanol was envisioned through the conversion of waste cellulose, first to glucose, and then by fermentation by yeast. To facilitate the initial hydrolysis of cellulose, hyper cellulolytic mutants were created.

SECONDARY METABOLITES

Trichoderma is a genus that produces a wide variety of secondary metabolites; more than 100 have been identified. These consist of pyrones, terpenoids, polyketides, oxygen heterocyclic compounds, polypeptides, and derivatives of fatty and amino acids. *Trichoderma viride* and certain strains of *Trichoderma hamatum* produce the volatile 6-pentyl- α -pyrone, which is responsible for the coconut smell connected to soils. There are pigments of unknown function, including the anthroquinonespachybasin (1,8-dihydroxy-3-methyl-9,10-anthraquinone), chrysophanol (1,8-dihydroxy-3-methyl-9,10-anthraquinone), and emodin (1,6,8-trihydroxy-3-methyl-9,10-anthraquinone). Some secondary metabolites of Trichothecenes, cyclic peptides, and isocyanide-containing metabolites are the three categories of mycotoxin that the most well-known *Trichoderma* species belong to. *Trichoderma* are hazardous to both plants and animals. Trichothecenes, such as trichodermin, are speculated to be produced in the soil and impair plant growth. Cyclic peptides, including Alamethicin, suzukacillin, trichotoxins, trichopolyns, and trichorianine are lipophilic substances that assault bacterial and eukaryotic cell membranes to induce lysis. Similar to trichoviridin, isocyanides are another family of poisonous metabolites that *T. hamatum* strains are known to produce in large quantities. This species has been linked to sheep's poor thrift by suppressing their cellulolytic rumen microorganisms. It is a prominent soil bacterium in some sheep pastures. *Trichoderma* products are used in the food business under strict monitoring because of their possible toxicity.

TRICHODERMA IN BIOCONTROL OF PLANT FUNGAL PATHOGENS

Numerous strains of *Trichoderma* have been engineered as biocontrol agents to combat fungal diseases in plants. The mechanisms employed include antibiosis, parasitism, induction of host-plant resistance, and competition. These species work particularly well as biocontrol agents against soilborne root diseases as verticillium dahliae and Sclerotiasclerotiorum, wilts (*Sclerotinia sclerotiorum*), damping off (*Pythium* spp.), and cereal take-all (*Gaeumannomyces graminis*), as well as leaf pathogens like gray mold (*Botrytis* spp.). High-performing biocontrol strains have been identified, and large-scale production of conidiospores and chlamydospores has been established. Specialized methods for delivering these spores are being actively developed. Strains of *T. harzianum*, *T. viride*, and *T. hamatum*, along with strains of the closely related *Gliocladium*, are particularly effective. Commercial biotechnological products, such as 3TAC, have been developed using *T. harzianum* and have proven useful in treating *Botrytis*, *Fusarium*, and *Penicillium* sp. (Yedidia et al., 1999). *T. viride* is another species that serves as an effective biological control agent against plant pathogenic fungi, offering protection against pathogens such as *Rhizoctonia*, *Pythium*, and *Armillaria*. In agriculture, *Trichoderma* species are powerful biocontrol agents and are frequently applied to soils to control soil-borne pathogens and enhance crop yields globally. Over 250 products based on *Trichoderma* are thought to be available in India (Mendoza-Mendoza et al., 2015). Additionally, *Trichoderma* species are easily included into agricultural methods due to their innate tolerance to a variety of pesticides and fungicides used in agriculture (Liu and Zhang, 2015; Ons et al., 2020). Numerous metabolites with antibacterial, antifungal, and anticancer activities are produced in large quantities by *Trichoderma* species (Khan et al., 2020). Recently, there has been increased awareness of the function of volatile compounds produced by rhizobacteria in controlling plant growth and development. According to Ryu et al. (2003), certain strains of plant growth-promoting rhizobacteria (PGPR) generated a mixture of volatile organic compounds (VOCs) that promoted the growth of *Arabidopsis thaliana* seedlings. Additionally, airborne compounds from specific strains of *Bacillus* sp. have been shown to have a growth-enhancing impact by Gutiérrez-Luna et al. (2010). Farag et al. (2013) found that during their in vitro evaluation of



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rhizobacteria, bacterial volatile chemicals contribute to plant development. Numerous studies have examined the capacity of Trichoderma to regulate soil phytopathogens via a variety of intricate mechanisms, including mycoparasitism, competition for nutrients and space, pathogen cell wall disintegration, and induction of plant resistance. VOCs seem to be a good strategy. The majority of research has been on the effects of VOCs emitted by PGPR on the interactions between pathogens and plants. However, nothing is known about how PGPF that produces VOCs promotes plant growth and resilience (Tillocet *et al.*, 2020).

TRICHODERMA AS BIOCONTROL AGENT FOR DIFFERENT CROP DISEASES

Cereal crops

Rice (*Oryza sativa* L), the most extensively grown food crop worldwide, faces production challenges due to diseases of fungal, bacterial, and viral origins. Several species of Trichoderma, including *T. harzianum*, *T. viride*, *T. reesei*, *T. longibrachitum*, and *T. koningii*, have been evaluated by numerous researchers and found to be effective against these diseases when used in conjunction with chemical control. Sheath blight of rice, caused by *Rhizoctonia solani*, is a common and destructive disease in India. Wheat (*Triticum* spp. L.) is a globally significant cereal crop and a vital source of carbohydrates, proteins, vitamins, and minerals. Smut diseases are among the biotic constraints causing substantial yield loss and grain quality deterioration. The first report of biocontrol of a seed-borne disease, specifically loose smut of wheat, was demonstrated by Aggarwal *et al.* (1991), who used *T. viride* as a seed treatment. Trichoderma species such as *T. viride* (TV- 5), *T. koningii*, *T. hamatum*, *T. harzianum*, and *T. lignorum* were found to inhibit the germination of chlamydospores of the wheat pathogen *U. segetum* var. *tritici* (Mondal *et al.*, 1995). Maize (*Zea mays* L.), another crucial cereal crop, is affected by soil-borne and foliar pathogens. Efforts have been made to use Trichoderma against significant diseases of maize. Research conducted by Sankar and Sharma (2001) clearly demonstrated the effectiveness of *T. viride* in both *in vitro* and *in vivo* conditions in suppressing the charcoal rot disease caused by *Macrophomaphaseolina* and enhancing crop growth. A decade later, Khedekar *et al.* (2010) evaluated the efficacy of *T. harzianum* against leaf blight caused by *Helminthosporium turcicum* and found comparable results.

Pulse crops

Chickpea (*Cicer arietinum* L.) is a highly consumed pulse in numerous regions globally, accounting for 50% of the major pulse production in India. It is frequently affected by wilt caused by *Fusarium oxysporum* f. sp. *ciceri*, stem rot by *Sclerotinia sclerotiorum*, and damping off caused by *R. solani*, which are distributed worldwide. Initial investigations into the utility of Trichoderma as a biocontrol agent were conducted by Kaur and Mukhopadhyay (1992), who reported the successful combination of *T. harzianum* with fungicides like Vitavax 200 and Ziram in combating chickpea wilt. Sharma *et al.* (1999) identified *T. harzianum* and *Absidiocylinndrospora* as the most effective in inhibiting the mycelial growth of *S. sclerotiorum*, which causes stem rot in chickpea. Prasad and Rangeshwaran (2000) discovered that a modified wheat bran-kaolin granular formulation of *T. harzianum* was effective against *R. solani* under field conditions. In a separate field experiment, two antagonistic fungi, *T. harzianum* (PDBCTH 10) and *T. viride* (PDBCTV), were reported to be effective against chickpea wilt and wet root rot by Prasad *et al.* (2002). Black gram (*Vigna mungo* L.) and green gram (*Vigna radiata* L.), important pulse crops, have been gaining global importance in recent years. Kehri and Chandra (1991) were the first to report the antagonism of *T. viride* to *M. phaseolina* and its use in controlling dry root-rot of mung bean under greenhouse conditions.

Oilseed crops

Brassica juncea (L.), also known as Indian mustard, is a significant oilseed crop in India. A number of studies have focused on eco-friendly methods to manage its major diseases using Trichoderma. One such *in vitro* study showed that *T. viride*, in combination with the fungicides mancozeb and carbendazim, was effective against the mycelial growth of *Alternaria brassicae* (Meena *et al.*, 2004). Soybean (*Glycine max* L.), the third most important oilseed crop, has been the subject of numerous research efforts to develop integrated management strategies for root, seed, and foliar diseases. Singh and Thapliyal (1998) discovered that pre- and post-emergence seedling rot may be successfully controlled by treating seeds with Vitavax 200 combined with *T. harzianum* or *G. virens*. Using biocontrol agents



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Gliocladium virens and *T. harzianum*, Pant and Mukhopadhyay (2001) reported successful management of the soybean seed and seedling rot complex induced by *R. solani* in an in vitro investigation. Because of the high incidence of illness, groundnut (*Arachis hypogaea* L.) yields are frequently decreased. A few diseases include early leaf spot (*Phaeoisriopisarichidicola*), late leaf spot (*Phaeoisriopisersonata*), rust (*Puccinia arichidis*), collar rot (*A. niger van tiegham*), and stem rot (*S. rolfsii*), despite the fact that over 55 pathogens have been identified to damage the crop, root rot (*M. phaseolina*) and alfalfa root (*Aspergillus flavus*) are considered economically important and have been biologically managed by deploying *Trichoderma* spp. Sesame (*Sesamum indicum*), one of the oldest oil-seed crops, has been investigated for the ability of gaseous metabolites from *N. sitophila* and *T. harzianum* to prevent the growth of a variety of fungus that cause sesame wilt. According to Tamimi and Hadvan (1985), age differences may have contributed to the variations in inhibition levels. The following represents the highest level of growth inhibition from test fungus ever observed: Three-day-old *N. sitophila* was found to be 51% on a virulent *R. solani*, 48% on *F. oxysporum*, 40% on *M. phaseoli*, and 55% on virulent *R. solani*. Nevertheless, *N. sitophila* outperformed *T. harzianum* and a few other soil-borne fungi in the test conditions.

Sunflower (*Helianthus annuus*), the third-largest edible oil seed crop in the world, is frequently impacted by fungal diseases including *M. phaseolina*'s charcoal rot and *Plasmoparahalstedii*'s downy mildew. *M. phaseolina*-induced charcoal rot was treated with carbendazim-tolerant *Trichoderma* species (Nagamani and Reedi Kumar, 2011). In comparison to the matching wild type strain TW17 (62.2%), the mutant strain TM17 suppressed the test pathogen's mycelial development by 90%, suggesting that the enhanced antagonistic action is genetically regulated. According to Nagarajuet al. (2012), beneficial bacteria encourage plant growth and create systemic resistance in sunflowers against *Plasmoparahalstedii*-caused downy mildew disease. The most prolific vegetable oil source is oil palm, which yields four to six tonnes of oil per hectare annually. *T. harzianum* and *T. koningii* were shown to have greater lignocellulytic capacity than other isolates, suggesting that they could be used as bioagents for the quick bioconversion of lignocellulosic oil palm empty fruit bunches (Mukhlis et al., 2013). According to Singh et al. (2013), two foliar sprays of mancozeb should be applied after treating seeds with *T. viride* for integrated management of Alternaria blight in linseed.

Cash crops

Tobacco (*Nicotiana tabacum*) is susceptible to serious diseases caused by various soil-dwelling fungi such as *F. oxysporum*f.sp. *nicotianae*, *Pythium* spp., and *R. solani*, as well as the root-knot nematode, *Meloidogyne incognita*. Tests have been conducted on *T. harzianum*'s antagonistic activity against *P. aphanidermatum* and *P. myriotylum*, which induce tobacco root rot (Devaki et al., 1992). In vitro tests have also been performed on *F. oxysporum*f.sp. *nicotinae* (Sumana and Devaki, 2012) and *M. incognita* (Khan et al., 2011). A major commercial crop in tropical and sub-tropical areas, sugarcane is severely yield-depleted by fungi like red rot and smut. Red rot incidents have an impact on the rhizosphere microbiota of sugarcane plants, according to Mishra (1982). Subsequent research revealed that *Colletotrichum falcatum*, the cause of red rot in sugarcane, was suppressed by the secondary metabolites of a *Trichoderma* isolate that was indigenous to the ecosystem (Joshi and Misra, 2013). According to Malathi and Vishwanathan (2013), *T. harzianum* T5 *endochitinase* has been found to have antifungal properties against *C. falcatum*. Another study discovered that applying *T. viride* to the soil, either by alone or in conjunction with other treatments, greatly decreased the amount of *C. falcatum*-caused red rot (Reddy et al., 2009).

Major diseases like root rot (*M. phaseolina*), wilt (*Fusarium vasinfectum*), root rot (*Rhizoctonia bataticola*), anthracnose (*Collectotricumgossypium*), Alternaria leaf spot, bacterial blight, and damping off (*Pythium ultimum*) cause decreased yields in cotton, a commercial crop that is widely cultivated in India. Applying *Trichoderma* to the soil was shown to be far more successful than treating it with seeds (Gaur et al., 2005). The most devastating disease in the world, corm rot, threatens saffron (*Crocus sativus* L.), a low volume, high value perennial crop valued for its therapeutic properties (Gupta et al., 2011). According to a 2011 study by Hassan et al., native *T. viride* isolates could control the pathogens that cause corm rot in the field. Tea and coffee, popular beverage crops cultivated in over 50 countries, are impacted by illnesses such *R. solani*-caused coffee collar rot, *Glomerellacingulata*-caused brown blight, and *Phomopsis* theae-



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caused collar canker. Deb *et al.* (1999) examined the phyllosphere and soil mycoflora of an experimental tea plantation located in Cachar. At different stages, it was found that the isolates of *Trichoderma* JPT9 and *Gliocladium* JPG1 greatly suppressed the growth of *M. phaseolina*'s sclerotia (Bandopadhyay *et al.*, 2008). One main factor restricting coconut production is the basal stem rot disease produced by *Ganoderma lucidum*, which poses a danger to the coconut (*Cocos nucifera* L.), an important oilseed and plantation crop in India. For the purpose of multiplying the fungal biocontrol agent, naturally occurring agricultural waste such as coir pith has been recycled using *Trichoderma* spp. (Kumar *et al.*, 2000).

Vegetable crops

In the 1990s, it was discovered that applying *T. harzianum* or *P. fluorescens* to seeds or roots along with soil solarization was beneficial in controlling tomato, brinjal, and capsicum infections. The tomato, or *Solanum lycopersicum*, is a major vegetable crop that is grown all over India. However, it is susceptible to a number of diseases, including *Phytophthora infestans*, which causes late blight, *A. solani*, which causes early blight, *Fusarium oxysporum* f.sp. *lycopersici*, which causes wilt, *Phytophthora aphanidermatum*, which causes damping off, *Sclerotium rolfsii*, which causes collar rot, *Xanthomonas campestris* pv. *vesicatoria* causes bacterial leaf spot, and *Ralstonia solanacearum* causes bacterial wilt. *Allium cepa*, a vital vegetable crop in India, is linked to six main diseases: *Alternaria alternata* causes foliar blight, *Alternaria porri* causes purple blotch on onions, *Fusarium oxysporum* f.sp. *cepae* and *Pythium* sp. causes damping-off and basal rot, *S. rolfsii* causes white rot, and *A. niger* causes black mould. The management of *A. porri*, the bacterium that causes purple blotch on onions, has been thoroughly investigated. According to reports, susceptible onions can develop more quickly and have a considerable reduction in disease when exposed to *T. harzianum* isolates Th3, Th-30, and Tv-12, Tv-15 of *T. viride* (Prakasam and Sharma, 2012). One of the most widely grown vegetable crops in the nation, aubergine or brinjal (*Solanum melongena* L.), is harmed year-round by a number of fungi, including *A. solani*, *F. solani*, *C. gloeosporioides*, *B. cinerea*, *Penicillium* sp., *Rhizopus niger*, *Curvularialunata*, and *Botryodiplodiatheobromae*. According to a 2009 study by Jadon, *T. viride* is the most efficient in lowering the frequency of *S. rolfsii*-caused collar rot. Chilli (*Capsicum annum*), another important vegetable crop that is also used as a spice and is rich in vitamins C, A, and B, is widely affected by fungal diseases such as damping off caused by *S. rolfsii*, *F. oxysporum*, *Pythium* spp., *R. solani*, and *Phytophthora* sp. Several studies have revealed that isolates of *T. harzianum*, *T. viride* (TVC3), and *T. hamatum* are effective bio-control agents against anthracnose, damping-off, and chilli dieback disease. A study suggested that using coco-peat enriched with *T. harzianum* could enhance plant growth and reduce the incidence of tomato wilt and chilli root rot. This approach also helped in raising disease-free and healthy seedlings, which further reduced wilt incidence in tomato (Sriram *et al.*, 2010).

Major diseases afflict the two main winter vegetables of India: cabbage (*Brassica oleracea* L. var. *capitata*) and cauliflower (*Brassica oleracea* L. var. *botrytis*). *Plasmiodiophorabrassicarum* causes club root, *Xanthomonas campestris* causes black rot, *Rhizoctonia solani* causes wire stem, *A. brassicae* causes leaf spot, *A. brassiciola* causes leaf blight, and *Pythium*, *Phytophthora*, *Corticium*, and *Fusarium* cause damping off. Sugar beet (*Beta vulgaris* L. ssp. *vulgaris* var. *altissima* Doll. Chenopodiaceae), a significant sugar-producing tuber crop, suffers from serious diseases like root rot caused by *S. rolfsii* and *Pythium* spp., leading to substantial yield losses. Several reports have highlighted the use of *Trichoderma* spp. as bioagents to combat these pathogens. One such report by Sawant and Mukhopadhyay (1990) discussed the integration of metalaxyl with *T. harzianum* for controlling *Pythium* damping-off in sugar beet. Many diseases endanger the potato (*Solanum tuberosum*), a vital food crop in the world that lowers its output. These include black scurf, dry rot (*Fusarium* spp.), common scabies (*Streptomyces scabies*), late blight (*Phytophthora infestans*), and bacterial wilt (*Ralstonia solanacearum*). Potato germination and yield are thought to be significantly influenced by the antagonistic fungus population (Dwivedi, 1988).

Fruit crops

Guava (*Psidium guajava*), a significant fruit crop in India, is affected by various pre-harvest diseases such as canker, die back, and decline, which impact plant growth and production. Post-harvest diseases like *Phytophthora*, *Macrophomina*, and others spoil the fruits in the field, during storage, and in transit. *Gliocladium roseum* has been



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identified as a potent pathogen, along with *F.o.f.sp. psidii* and *F. solani*. The mycoflora associated with seeds from healthy and rotten fruits of guava was observed by Pandey and Dwivedi (1987). Subsequently, several groups have evaluated and utilized Trichoderma technology to combat diseases in fruits like guava. Sapodilla (*Manilkara zapota*), a fruit cultivated throughout India, has been the subject of studies testing the antagonistic potentials of five *Trichoderma* species: *T. viride*, *T. harzianum*, *T. koningii*, *T. pseudokoningii*, and *T. virens* against fruit rot pathogens (Bhalleet al., 2013). Mango (*Mangifera indica*), a prominent fruit crop in India, suffers significant economic loss due to various pathogens, including *F. moniliforme var. subglutinans* causing mango malformation. Biocontrol has been used successfully against different pathogens. Bhuvaneshwari and Rao (2001) studied the in vitro interaction of *T. viride* with the postharvest pathogens of mango and found that *T. viride* inhibited the growth of *Pestalotiasp.*, *A. flavus*, *L. theobromae*, *C. gloeosporioides*, *R. stolonifer*, *A. niger*, and *M. phaseolina* by 72.88, 70.74, 62.41, 56.83, 54.60, 52.77, and 51.08%, respectively. Citrus crops are also affected by serious diseases such as root rot by *Phytophthora* spp., dry root rot by *M. phaseoli*, pink disease by *Alternaria citri*, and powdery mildew by *C. gloeosporioides*. The role of phylloplane microflora in managing citrus canker was established by Kalita et al. (1996). Later, Singh et al. (2000) managed citrus scab caused by *Elsinoefawcettii* and found that *T. harzianum* and *E. purpurascens* reduced the disease incidence in the field by 17.8 and 10%, respectively.

Spices crops

Black pepper (*Piper nigrum*), often referred to as the king of spices, has a long history of cultivation in India. One of the most severe diseases it faces is foot rot (quick wilt), caused by *Phytophthora capsici*. Two species of *Trichoderma*, *T. virens*-12 and *T. harzianum*-26, have been identified as potential biocontrol agents against this disease in both greenhouse and field trials (Sarma et al., 2000). Small cardamom (*Elettaria cardamomum* Maton) is another spice that suffers from rhizome rot, a disease caused by *P. vexans*, *R. solani*, and *F. oxysporum*. This disease is a major issue in India, leading to a 30% loss in yield. The effectiveness of the *T. harzianum* isolate in managing this disease, in combination with chemicals and fertilizers, was later confirmed (Bhai and Thomas, 2010). Cumin (*Cuminum cyminum* L.) is affected by wilt caused by *Fusarium oxysporum* f.sp. *cumini*, a major disease for this crop. The in vitro and in vivo effectiveness of two *Trichoderma* species, *T. harzianum* and *T. viride*, in suppressing wilt caused by *Fusarium oxysporum* f. sp. *cumini* has been documented (Chawla and Gangopadhyay, 2009).

Other crops

Bhattiprolu (2008) conducted a study on the antagonism of *T. viride* against *Botrytis ricini* (castor grey rot). The study found that the optimal pH range was 5.0 to 6.0, with an incubation temperature of 25°C. The isolate was compatible with 10% leaf extracts of several plants and common fungicides, but not with certain others. Carnation (*Dianthus caryophyllus* Linn.), a valuable cut flower crop, is primarily cultivated in controlled conditions. Its cultivation, like any monoculture, is affected by numerous diseases leading to significant yield losses. It was determined which *Trichoderma* spp. were antagonistic to *Fusarium oxysporum* f.sp. *dianthi*, which causes carnation wilt. A seasonal but long-lasting cut flower crop, gladiolus (*Gladiolus hortulanus* L.H.Bailey) creates a stable microclimate that is favourable to a number of diseases. In vitro experiments have demonstrated the efficacy of native isolates of *Trichoderma* spp. against *Fusarium oxysporum* f.sp. *gladioli*. *Fusarium oxysporum* f.sp. *gladioli* causes vascular wilt and corm rot, which significantly reduce crop output and lower the quality and quantity of spikes and planting materials (Pan and Das, 2004).

TRICHODERMA – A PROMISING PLANT GROWTH STIMULATOR

Trichoderma is capable of producing plant growth promoters like harzianolide and indoleacetic acid (IAA). By secreting phytase and ferritin, these stimulators encourage the growth and development of plant roots, which in turn improves the absorption of iron (Fe) and phosphorus (P) by plants. Additionally, according to Lombardi et al. (2020a), trichoderma breaks down organic matter in the soil, increases the availability of nutrients, raises crop photosynthetic efficiency, improves plant height, stem diameter, and other agronomic features, and increases production. Trichoderma can improve the availability and efficiency of soil nutrient utilisation. Cucumber seedlings injected with Trichoderma MF-2 showed a 39.07% increase in aboveground biomass, indicating a substantial growth-



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promoting impact. Additionally, as a result, the soil now contains more advantageous bacteria (Singh *et al.*, 2019; Ye *et al.*, 2020). The application of *Trichoderma* wettable powder treatment greatly increased banana production, and different strains of *Trichoderma* showed variable degrees of antagonism to *F. oxysporum* (Samuelian, 2016; Bubiciet *et al.*, 2019; Damodaran *et al.*, 2020). Applying *Trichoderma* can improve the primary agronomic characteristics of peanuts, raise the SPAD value of chlorophyll in peanut leaves, dramatically increase the activity of protective enzymes in peanut roots, stems and leaves, and lower the amount of MDA (Kováčset *et al.*, 2021; Al-Askar *et al.*, 2022). In comparison to the control, there were increases of 24.63, 20.22, 14.10, 4.86, 7.63, and 12.85% in the number of pods per plant, pod weight, seed kernel weight, 100 fruit quality, 100 fruit kernel quality, and yield per plant of peanut when applied at a rate of 1.5 kg/666.7 m⁻² (Al-Askar *et al.*, 2022).

Mechanism of Action

Trichoderma can greatly increase the Na⁺ outflow from *Lycium barbarum*'s root system and its movement to the plant's above-ground sections. This lessens the harm that ion toxicity and oxidative stress produce to PSII by guaranteeing K⁺ absorption and preserving the ion equilibrium in the plant. Additionally, it lessens biomass loss, preserves photosynthetic pigments, and keeps *L. barbarum* performing as a photosynthetic under salt stress (Brotmanet *et al.*, 2013). One of *Trichoderma*'s main mechanisms is the manufacture of plant growth hormones, including IAA, ABA, ET, GA, and CK (Karuppiyah *et al.*, 2019b; Wang *et al.*, 2021; Deganiet *et al.*, 2021b; Agbessenouet *et al.*, 2022). Cucumber has been demonstrated to create IAA, GA, and ABA when exposed to *T. asperellum*, which encourages development (Liu H. *et al.*, 2022). According to a different study, *T. asperellum* has the ability to significantly promote poplar development by upregulating the expression of xylanase genes (Karuppiyah *et al.*, 2019b). By increasing the activities of succinate dehydrogenase and glucose-6-phosphate dehydrogenase, *T. harzianum* has been shown to modulate the tricarboxylic acid cycle (TAC) and hexose monophosphate pathway (HMP) to increase tomato growth (Manganiello *et al.*, 2018). *Trichoderma* generates acidic compounds that have the ability to dissolve intractable trace minerals from soil, giving plants additional nutrition (Samuelian, 2016).

Trichoderma in Plant Growth

Recent findings indicate that *Trichoderma* spp. are opportunistic, exhibiting both virulent plant symbiosis and parasitism of other fungi. Certain strains are known to establish durable colonizations of root surfaces, penetrating the epidermis and a few cells beneath. These strains produce or release various compounds that trigger localized or systemic resistance responses, explaining their non-pathogenic nature towards plants. Furthermore, it has been noted that the parasitic relationship between *Trichoderma* spp. and several pathogenic fungi induces the synthesis of specific lytic enzymes (Haran *et al.* 1996). Depending on the strain, *T. harzianum*'s chitinolytic system consists of five to seven different enzymes (Haran *et al.* 1995). The system appears to consist of four endochitinases (52, 42, 33, and 31 kDa) and two β -(1,4)-N-acetylglucosaminidases (102 and 73 kDa) in the best-characterized *Trichoderma* isolate (isolate TM). It is probable that the various enzyme components of *T. harzianum*'s chitinolytic system operate in complimentary ways. Of special significance is the 42-kDa endochitinase (Ech42), which has been demonstrated to hydrolyze the cell walls of *Botrytis cinerea* in vitro and to prevent the elongation of germ tubes and spore germination in a variety of fungi (Schirmböcket *et al.* 1994). When a fungus is grown in the presence of autoclaved mycelia from many fungi or with colloidal chitin as the only carbon source, the corresponding gene (ech42) is substantially stimulated (Carsolioet *et al.* 1994).

Trichoderma in Stress Tolerance

Trichoderma spp. are endophytic plant symbionts that are commonly used as seed treatments to control diseases and enhance plant growth and yield. Despite recent research on their ability to alleviate abiotic stresses, there is still a lack of specific knowledge about their mechanisms, their ability to control multiple plant stress factors, and their effects on seeds and seedlings. Under stress conditions, seeds treated with *Trichoderma* spp. germinate faster and more uniformly than untreated seeds, regardless of whether the stress is osmotic, salt, or due to suboptimal temperatures. Biocontrol is often associated with the ability of these fungi to produce antibiotics, establish parasitic interactions, or directly affect pathogens (Howell, 2003, 2006). However, it has become clear that beneficial fungi like *Trichoderma* spp. can induce systemic resistance in many cases, mediated by alterations in plant gene expression (Alfano, 2007,



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Shoresh & Harman 2008, Shoresh et al., 2010). Reports also suggest that plant growth can be enhanced as a result of the association of *Trichoderma* strains with plants, especially when plants are under suboptimal conditions or biotic, abiotic, or physiological stresses (Bae et al., 2009, Mastouri Harman 2009). Recent reports suggest that these fungi enhance plant tolerance to abiotic stresses during growth (Yildirim et al., 2006), partly due to improved root growth, increased water-holding capacity of plants, or enhanced nutrient uptake (i.e., potassium). In the absence of stress, plant growth may or may not be enhanced. Molecular studies indicate greater expression of gene families involved in plant protection against abiotic stresses or oxidative damage (Alfano et al., 2006, 2007, Bailey et al., 2006) in plants treated with *Trichoderma* spp. However, no experimental evidence has been presented that correlates enhanced tolerance of plants colonized with biocontrol fungi to these changes at the molecular level.

Trichoderma in Mycoparasitism

A *Trichoderma* species engages in a complicated process called mycoparasitism in which it grows chemotropically towards its host, adhering to, coiling around, and occasionally piercing the host hyphae. The antagonistic activities of antibiosis, competition, the generation of enzymes that break down cell walls, or a combination of these could be the cause of *Trichoderma* spp.'s mycoparasitic activity (McGrew & Green 1990). Partial breakdown of the host cell wall is typically seen in the later phases of the parasite infection. Histochemical and/or ultrastructural methods have been used to study the effects of cell wall-degrading enzymes on the host. In addition, other cell wall-degrading enzymes, including those that hydrolyze minor polymers (proteins, b-1,6- glucans, a-1,3-glucans, etc.), may play a role in the effective and complete degradation of the mycelial or conidial walls of phytopathogenic fungi by *Trichoderma* spp. *Trichoderma* spp. are employed as biocontrol agents against several plant pathogenic fungi, including *Rhizoctonia* spp., *Pythium* spp., *Botrytis cinerea*, and *Fusarium* spp.

Trichoderma in Anti-Fungal Activity

Trichoderma species, known as mycoparasites, are commercially utilized as biological control agents against plant-pathogenic fungi such as *Rhizoctonia solani*, *Botrytis cinerea*, *Sclerotium rolfsii*, *Sclerotinia sclerotiorum*, *Pythium* spp., and *Fusarium* spp. These are used in various countries including the United States, India, Israel, New Zealand, and Sweden, serving as a promising alternative to chemical pesticides (Howell, 2003). The genus *Trichoderma* has been widely recognized for its antagonistic activity against *F. solani* and *R. solani* (Lewis et al., 1998). *Trichoderma harzianum* has been observed to protect bean seedlings from pre-emergence damping off infection, reducing disease severity and promoting plant growth in the presence of the *R. solani* pathogen (Paula et al., 2001). El-Kafrawy (2002) reported that *T. harzianum*, *T. hamatum*, *T. pseudoknonningii*, and *T. polysporum* inhibited the radial mycelial growth of *R. solani* *in vitro*, with inhibition rates ranging from 59.6% to 78.4%. The application of *Trichoderma* fungi in agriculture offers several benefits: 1) colonization of the root and rhizosphere of the plant, 2) control of plant pathogens through various mechanisms such as parasitism, antibiosis production, and induced systemic resistance, 3) enhancement of plant health by promoting plant growth, and 4) stimulation of root growth (Abd-El-Khair et al., 2010)

NANO FORMULATION

Nanotechnology, a swiftly expanding field, has demonstrated significant impact in various sectors including medical sciences, energy, cosmetics, and agriculture. It offers an understanding of antimicrobial properties at the atomic and molecular level, which helps in reducing the cytotoxic effect on cells. Nanoparticles, known for their stability under severe conditions, possess the potential to manage a variety of diseases due to their antimicrobial properties. The application of insecticides, including pesticides and fungicides, can be reduced by agricultural cultivators through the use of nano-delivery systems. Formulations based on nanoparticles could serve as alternatives to fungicides and provide an eco-friendly solution for managing plant pathogenic microbes. Nanoparticles, particularly those composed of metals in oxide form, play a crucial role in magnetism, electrochemistry, and environmental science. These metal oxide-based nano formulations are stable, environmentally friendly, and safe for humans. In the current scenario, the agricultural sector is experiencing a high demand for food products. This necessitates that the soil be enriched with all essential nutrients and possess suitable properties for the optimal growth of crops. Crops are vulnerable to attacks by phytopathogens, necessitating the use of agrochemicals such as fertilizers and pesticides to



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mitigate the adverse effects caused by these pathogens. The recent emergence of agrochemicals containing nanostructured materials offers a promising alternative in agriculture. Various methods exist for the synthesis of nanoparticles, including chemical, physical, and physico-chemical techniques. These methods, however, face challenges due to the use of toxic solvents, reducing agents, expensive metal salts, reductants, and costly equipment. Consequently, researchers have turned their attention towards finding simple, eco-friendly, and non-hazardous alternative methods. In this regard, green nano-chemistry has received significant attention for its potential to replace chemical products and develop green synthesis methods that eliminate substances harmful to the environment and human health. Silver, in various chemical forms as well as in green nano form, is highly toxic. Its nanoparticles have attracted considerable interest due to their potent antimicrobial effects. Some studies have found that the toxicity of silver-based nanoparticles is dependent on both dosage and particle size. Certain phytopathogens, which are nonpathogenic in nature, can be used for mass production of green silver nanoparticles (Ag-NPs).

Among the primary nanoparticles (NPs) used in agriculture are zinc oxide NPs (ZnONPs), copper oxide NPs (CuONPs), and silver NPs (AgNPs). These can be acquired by means of chemical, biological, and physical processes. In addition to being costly, physical and chemical processes include ultraviolet radiation, aerosol technologies, lithography, laser ablation, ultrasonic fields, and photochemical reduction involve the use and discharge of hazardous substances that pollute the environment. The biosynthesis of certain metal nanoparticles, on the other hand, provides an easy, affordable, large-scale, and ecologically friendly substitute. According to reports, because biosynthesized NPs are stabilised with organic chemicals and do not produce any hazardous residues during the synthesis process, they are less dangerous than NPs obtained chemically. Better biocompatibility when using NPs is another benefit of these environmentally friendly production techniques. Plant extracts, bacteria, fungi, algae, yeasts, and the byproducts of their metabolism, such as enzymes, agro-industrial waste, and microbial pigments, can all be used in biosynthesis. According to reports, elemental metal biosynthesis is aided in the conversion of ions into secondary metabolites and other substances secreted by bacteria as a defence mechanism. Certain species that exhibit resistance to metals can release molecules that function as stabilising and reducing agents during the creation of metallic nanoparticles. The physicochemical features of the nanoparticle surface interact with their surroundings through the action of these cappings, which are stabilising or protecting substances. It is significant to remember that the pH affects how stable the cappings are: at high pH levels, the NPs stay stable in solution, but at low pH levels, the proteins that make up the cappings denature. Filamentous fungi stand out among microorganisms for nanoparticle (NP) biosynthesis due to their efficiency compared to other biological alternatives. This efficiency stems from the ease of large-scale cultivation and biomass collection, high tolerance to metals, resistance to high pressure and agitation fluxes, and the production of a large number of extracellular proteins. The secretion of these proteins by fungi has been observed to enhance the synthesis of NPs. A key advantage of utilizing fungi over bacterial systems is that NPs precipitate outside the cell, eliminating cellular contaminants. This allows for the direct application of these NPs in various fields. Consequently, fungi have emerged as valuable agents for the biosynthesis of NPs, a process known as mycosynthesis. The primary fungi employed for this purpose include *Fusarium*, *Aspergillus*, *Penicillium*, and *Trichoderma*.

Trichoderma as a synthesizer of NPs

Enzymes like reductases can aid in the mycosynthesis of nanoparticles (NPs) mediated by *Trichoderma* by acting as bio-reductive agents throughout the biofabrication process. Based on the qualities and traits of the several metallic nanoparticles that were obtained, it appears that *Trichoderma* may be a reliable source for the biological production of nanoparticles. Furthermore, the production of proteins, enzymes, and secondary metabolites that are involved in the biological control of plant diseases can improve the stability and biological activity of the resultant NPs. The antibacterial activity of NPs produced by *Trichoderma* spp. has been shown against a range of microbes, including phytopathogens including *Fusarium*, *Aspergillus*, *Pseudomonas*, and *Xanthomonas*. When performing mycosynthesis, it is essential to optimise the mono-dispersity, stability, and biocompatibility of the NPs by taking into account the parameters employed as well as the unique qualities of the fungal strains. It has been observed that the nucleation and subsequent generation of metallic NPs, along with their size and shape, are controlled by variables like temperature, starting pH, reagent concentration, fungal growth conditions, and reaction duration. *Trichoderma*



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produces a number of different nickel-based polymers (NPs), each with unique properties and antibacterial properties, such as gold (AuNPs), zinc oxide (ZnONPs), copper (CuNPs) and copper oxide (CuONPs), selenium (SeNPs), and silver (AgNPs).

Biosynthesis of AgNPs

Silver nanoparticles (NPs) are highly sought after due to their extensive antimicrobial spectrum, which includes plant pathogens, and their high bioactivity. The application of silver NPs (AgNPs) can enhance the effectiveness of agrochemicals and decrease the usage of pesticides and biocides. There are two mechanisms for the mycosynthesis of NPs: intracellular and extracellular, with the latter being more commonly used as it eliminates the need for NP extraction from cells. In this process, biomolecules secreted by the fungus catalyze the reduction of the metal precursor (AgNO₃ salt), resulting in the formation of AgNPs. The characteristics of the AgNPs produced through mycosynthesis can be varied depending on the fungal culture and production conditions. It has been noted that reductases are the primary enzymes involved in the biosynthesis of metal NPs in fungi. Among these, the nicotinamide adenine dinucleotide (NADH)-dependent nitrate reductase is prominent, playing a key role in the reduction of metal ions. For instance, *T. reesei* produces extracellular enzymes capable of reducing silver ions to AgNPs, with the NADH-dependent nitrate reductase facilitating the reduction of Ag⁺ metal ions into metallic AgNPs. This reduction is facilitated by the transfer of an electron from NADH, with the nitrate reductase serving as the electron carrier. Proteins can also bind to NPs, enhancing their stability. Additionally, it has been described that the reduction of silver to NPs can also be achieved by anthraquinones, naphthoquinones, and quinine derivatives, which can act as electron carriers in the reaction (Khan *et al.*, 2023).

Biosynthesis of SeNPs

Selenium (Se) is known to have positive effects on plant and animal metabolism at low concentrations. It also plays a role in protecting against reactive oxygen species (ROS) in the form of selenoproteins, as reported by B^{ar}bieur *et al.* (2019). Therefore, Selenium nanoparticles (SeNPs) could serve as an alternative to Se salts. In terms of SeNPs synthesis, Hu *et al.* (2019) compared a traditional synthesis method (SNP, SeNPs) and a biosynthesis method (TSNP, SeNPs by *Trichoderma*). For the biosynthesis, a 5mM NaSeO₃ concentration was applied to a solution of metabolites from eight *Trichoderma* species. The SNP method resulted in SeNPs with spherical and pseudospherical shapes of 50 nm, along with the presence of polysaccharides. The TSNP method, on the other hand, yielded SeNPs of 60 nm with an irregular shape, likely due to the capping effect. The study also found an increased presence of amide materials in TSNP compared to SNP, which act as stabilizing agents (cappings). Three distinct media were used to assess the generation of SeNPs in a different investigation by Nandini *et al.* (2017): culture filtrate (CF), cell lysate (CL), and crude cell wall (CW). Each medium contained six distinct species of *Trichoderma* spp., and a concentration of 25 mM Na₂SeO₃ was utilised. As a result, the range of SeNPs in each medium was 49.5 to 312.5 nm. The outcomes showed that, in comparison to CL and CW, CF was the most efficient medium for producing nanoparticles because it made the procedure simpler. In their analysis of other mycosynthesis-related factors, Dikoet *et al.* (2020) looked at the impacts of pH, inoculation time, and SeO₂ concentration. The ideal circumstances (pH of 8, 2 mM SeO₂ concentration, 24 hours of SeO₂ inoculation, and *Trichoderma* sp.) resulted in the production of 20–220 nm spherical and pseudospherical SeNPs. Alkene, alkane, and alcohol functional groups indicated that they were involved as capping in the SeNPs production pathway.

Biosynthesis of AuNPs

According to do Nascimento *et al.* (2021), gold nanoparticles (AuNPs) have a variety of uses in the biomedical area, such as diagnostics, biomolecule detection, and as nanodrug carriers. They can also be used as catalysts and antibacterial agents. According to several studies (Mishra *et al.*, 2014; Abdel-Kareem and Zohri, 2018; Tripathi *et al.*, 2018; Elegbede *et al.*, 2020), AuNPs have antimicrobial activity against a variety of pathogens, including *Aspergillus niger*, *Aspergillus flavus*, *Aspergillus fumigatus*, *Escherichia coli*, *Klebsiella granulomatis*, *Pseudomonas aeruginosa*, *Aspergillus aureus*, and *Shigella sonnei*. In contrast to the electrochemical treatment of reverse osmosis and ion exchange resins, the biosynthesis of AuNPs is thought to be a more economical and ecologically benign method of recovering gold (do Nascimento *et al.*, 2021). *T. harzianum* can biosorb 1,340 mg of gold per g of biomass in 180



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minutes, according to a study by do Nascimento *et al.* (2021). This process produces spherical nanoparticles smaller than 30 nm through mycosynthesis. Abdel-Kareem and Zohri (2018) exposed *T. hamatum* SU136 to three distinct concentrations of Au₂C₁₆ (0.25, 0.5, and 1mM) in their investigation of the ideal parameters for mycosynthesis. All settings resulted in AuNPs; however, 0.5 mM Au₂C₁₆ at pH 7 and 38 °C was the ideal combination to make smaller nanoparticles.

Biosynthesis of CuNPs and CuONPs

According to Salvadori *et al.* (2014b), copper nanoparticles (CuNPs) have a wide range of uses, such as high-temperature conductors, gas sensors, catalysts, solar cells, and wood treatment. Furthermore, it has been discovered that they possess antibacterial properties against phytopathogens (Natesan *et al.*, 2021). Their high surface-to-volume ratio is thought to be responsible for their easy contact with other particles, which can boost their antibacterial activity (Al-Hakkani, 2020). According to Saravanakumaret *al.* (2019), *T. asperellum* uses the amino and aromatic groups of secondary metabolites as reducing agents or encapsulants in the synthesis of CuONPs. The dead biomass of *T. koningiopsis* was utilised in the mycosynthesis of CuNPs by Salvadori *et al.* (2014b) because it had a greater affinity for copper and a better capacity for metal ion adsorption (21.1 mg/g) than the live biomass and other biosorbents. Ninety percent of the nanoparticles were obtained in 60 minutes, indicating a rapid procedure. 87.5 nm was the average diameter of the spherical CuNPs that were synthesised.

Biosynthesis of ZnONPs

Zinc oxide nanoparticles (ZnONPs) are among the nanoparticles most commonly used in agriculture due to their benefits to plants and soil microbiota, as highlighted by Shobha *et al.* (2020). They have demonstrated antifungal activities against various species such as *Fusarium* spp., *Botrytis cinerea*, *Penicillium expansum*, *A. niger*, and *Rhizopus stolonifera*. In addition, ZnONPs are recognized as effective antibacterial agents against a wide range of species (Consoloet *al.*, 2020). In a study by Shobha *et al.* (2020), ZnONPs were synthesized using three different *Trichoderma* isolates and their effectiveness was tested against *Xanthomonas oryzaepv. Oryzae*. The resulting ZnONPs exhibited unique shapes (hexagons and peaks) and sizes ranging from 12–35 nm. These nanoparticles could be produced sustainably and on a large scale.

CONCLUSION

Microorganisms are thought to be more environment friendly and natural alternative to the chemical treatment methods currently in use for the biological control of plant infections. There have been continuous attempts to use *Trichoderma* species, which have been known for their antifungal qualities since the 1930s, to manage plant diseases. These species have been used as biostimulant and biological control agents; their isolates have been commercially made accessible for use in soil for agriculture. *Trichoderma* species are highly efficient biological control agents due to their diversity and diverse methods of action.

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Exploring Challenges and Perceptions: Educators Recommendations on Gamified Educational Interventions in an Inclusive Classroom

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ABSTRACT

Examining the benefits and drawbacks of using gamified educational interventions in inclusive classrooms is the goal of this research. The goals of the research are as follows: (1) to determine how gamification affects participation in class, (2) examine the mediating role of implementation issues, and (3) determine the moderating function of educators' opinions. A representative sample of 384 educators took part in the research project and provided their opinions by filling out structured questionnaires. We analyzed the data using structured equation modeling (SEM). Statistical evidence suggests that as the amount of gamification in a course increases, student engagement grows; however, this link is moderated by implementation concerns. To examine the data, structured equation modeling (SEM) was employed. The statistics show that the more gamified a lesson is, the more engaged students are, with implementation challenges mediating the relationship between the two. When it comes to planning and implementing gamified educational interventions in inclusive classrooms, these results highlight how important it is to take into consideration the problems that may arise during implementation as well as the perceived beliefs of educators.

Keywords: gamified educational interventions, inclusive classroom, challenges, perceptions, student engagement





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INTRODUCTION

Traditional, passive learning methods are now considered outmoded due to the internet, advancements in information and communication technology, and the ever-changing nature of our modern society. (Ucar & Kumtepe, 2020). On the contrary, active learning strategies push teachers to stimulate students' inventiveness and help them acquire new skills. (Murillo-Zamorano et al., 2021). This is particularly the case with online education, which has grown in popularity as traditional classroom settings have grown increasingly inconvenient due to time and space constraints. All people's social, material, and moral lives were negatively impacted by the coronavirus's emergence and the global crisis it caused. However, many businesses and institutions have already begun to use distance learning as a means to ensure the long-term viability of their educational programs, further proving the significance of these applications. In distance learning environments, when peer support and collaborative learning are scarce and solo work is prioritized, it might be more challenging to encourage students to study and pay attention to the lecture. According to (Chang et al., 2015), The advent of new technological possibilities has greatly improved the viability and effectiveness of distance learning and teaching. Programs with gamification elements might be among the most successful technology strategies because people naturally enjoy and need to play games.

Strong emotional responses to games include wonder, annoyance, and happiness (Richard N. Landers , Gustavo F. Tondello & Andrew B. Collmus , Elisa D. Mekler, 2018). Researchers in the field of education are showing a lot of interest in the new trend of gamification as a means to combat student boredom and boost motivation, active learning, and engagement. (Baptista & Oliveira, 2019). To put it simply, gamification is "incorporating elements of game in a non-game context" (Hanus & Fox, 2015). By providing positive feedback, gamification in education encourages greater engagement, teamwork, and enjoyment from the learning process while also increasing student motivation and interest in the material. Reviews of the relevant literature have demonstrated that gamification significantly improves students' mental and physical health. Increased drive, confidence, happiness, flow, perceived value, and contentment are some of these outcomes. Improved performance on tasks, better overall grades, and higher scores are all examples of the former. Nevertheless, despite a large body of research on various game genres and gamified projects, there is still a dearth of study on challenge-based gamification applications in the literature (Legaki et al., 2020). An innovative and engaging method of gamification in education, challenge-based gamification makes use of resources such as points, badges, levels, and league tables to inspire and satisfy students need for achievements. It is believed to stimulate students curiosity about the material, encourage healthy competition among them, and guarantee their active engagement in class. Applying constructivist theory of learning helps shed light on the benefits of challenge-based gamification. This theory posits that active learning is best fostered via socially built learning chances. In other words, learning happens as a result of how a student interacts with their surroundings, the activities they engage in, and other people who try to assess their knowledge in the learning environment (Kumar Shah, 2019).

LITERATURE REVIEW

The current study intends to make several contributions to the field of educational research. First off, it appears that most gamification research is conceptual in nature, and there is a dearth of study on gamification implementations in higher education notably in the works that are now published in the field of education (Rincon-Flores & Santos-Guevara, 2021). By looking at challenge-based gamification through the prism of constructivist theory of learning, we can better comprehend its benefits. (Sailer & Homner, 2020). This agrees with the findings of the review research carried out by (Dichev et al., 2015), This highlighted the paucity of empirical research that integrate gamification into a real learning environment, even though there has been a boom of studies addressing gamification in education. Most of these studies have adopted a descriptive method. Second, there is conflicting data on gamification's capacity to improve learning, despite research that have examined its effects in the classroom. While some research (Varannai et al., 2017) showed that applying gamification produced positive outcomes like improved performance, increased motivation, and a positive attitude, other research (Toda et al., 2018) found no evidence that gamification improved



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students' knowledge or had any negative effect on their performance. According to (Bai et al., 2020) (Oliveira et al., 2021), It is still debatable how gamified learning affects students' motivation, flow, performance, and outcomes, according to this and other recent analytical studies. Additional study in this field is necessary in light of these results.. Thirdly, whereas much research on gamification has concentrated on its effects on students' cognitive learning (such as students' academic achievement), (Huang et al., 2020) Additional research on the affective or behavioral learning consequences of gamification is strongly encouraged by a meta-analysis. Our goal in this study is to close this gap by investigating students' motivation and flow—two crucial affective effects of a gamified learning environment. Last but not least, challenge-based gamification is a fresh, intriguing strategy that hasn't received much attention. Challenge-based gamification is highlighted by (Legaki et al., 2020), who also point out that there is a dearth of empirical research in this field. By providing students with a platform to engage in collaborative learning—sharing their knowledge, experiences, and insights—challenge-based gamification promotes active learning, in line with the constructivist tenets of education. (McPhail, 2016). Researchers expect academics to feel the effects of the present study's empirical results and the unique gamification platform's ability to promote active learning in a challenging setting..

Aim and Objectives

In order to improve educational practices' efficacy and inclusivity, The objective of this research is to delve into the mindsets and challenges surrounding the use of gamified educational interventions in inclusive classrooms. It also asks teachers for their opinions. The main objectives of the study are follows:

- In an inclusive classroom, to directly measure the effect of gamification level on student
- In an inclusive classroom, we want to see how teachers' views on gamified interventions influence the correlation between gamification intensity and student participation.
- Specifically, we want to learn more about how implementation hurdles affect the correlation between gamification intensity and participation in an inclusive classroom.

Hypothesis

H1: Higher levels of gamification in educational interventions will positively influence student engagement in an inclusive classroom.

H2: opinions held by educators moderate the association between gamification level and student engagement. Educators' positive opinions of gamified interventions will lead to a larger impact of gamification on student engagement.

H3: Implementation difficulties will moderate the relationship between gamification level and student engagement, meaning that more gamification means more difficulties, which means less engagement from students.

METHODOLOGY**Conceptual framework****Sample size**

The research on "Exploring Challenges and Perceptions: Educators' Recommendations on gamified Educational Interventions in an Inclusive Classroom" features a carefully chosen sample of 384 participants, striking a balance between reliability and manageability. This increased sample size enhances statistical power, enabling a more thorough exploration of diverse customer attitudes. Aligned with structural equation modeling (SEM) principles, this deliberate choice underscores the study's commitment to producing credible and meaningful results

Sampling technique

In our research on "Exploring Challenges and Perceptions: Educators' Recommendations on gamified Educational Interventions in an Inclusive Classroom" we utilized random sampling to ensure a comprehensive and representative participant selection. We divided the population based on key characteristics such as Gender, Age, Education Level, Employment Status, and randomly selected individuals from each group. This approach aimed to



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capture diversity, enhancing the accuracy and dependability of our data by examining potential variations in outcomes across different demographic groups within the Educational Revolution.

Data collection

Our study on "Exploring Challenges and Perceptions: Educators' Recommendations on gamified Educational Interventions in an Inclusive Classroom" involved 384 participants surveyed through structured questionnaires. Ethical considerations were prioritized, ensuring informed consent and data security. A stratified random sampling method, considering demographics, was used for inclusivity. Participants chose between in-person interviews or online surveys for flexibility. This approach aimed to gain reliable insights into diverse "Exploring Challenges and Perceptions: Educators' Recommendations on gamified Educational Interventions in an Inclusive Classroom"

Data analysis

In our analysis of "Exploring Challenges and Perceptions: Educators' Recommendations on gamified Educational Interventions in an Inclusive Classroom" we used Structural Equation Modeling (SEM) and moderation analysis and Mediating and Moderating analysis to explore the interconnections between key factors influencing challenges in Implementation and perceptions of gamification. Our data analysis, encompassing descriptive and inferential statistics, rigorously tested hypotheses and provided crucial insights into Exploring Challenges and Perceptions: Educators' Recommendations on gamified Educational Interventions in an Inclusive Classroom.

Analysis of Structural Equation Modelling (SEM)

As part of our research, we used Structural Equation Modelling (SEM) is used to examine intricate interplay between numerous factors all at once. SEM integrates regression and factor analysis, providing a comprehensive understanding of relationships within a theoretical framework. It helps verify and adjust research hypotheses, revealing detailed patterns and insights into the dynamics between MSME performance management, modern marketing strategies, and digital marketing capabilities.

Inclusion and Exclusion Criteria

- Educators actively involved in teaching or supporting students in an inclusive classroom environment.
- Educators who have experience or expertise in utilizing or have been exposed to gamified educational interventions.
- Educators willing to participate in the study and share their perceptions and recommendations regarding gamified educational interventions in an inclusive classroom setting

Exclusion Criteria

- Educators who do not have experience or exposure to gamified educational interventions.
- Educators who are not currently teaching or supporting students in an inclusive classroom environment.
- Educators unwilling or unable to participate in the study and share their perspectives on the topic.
- Educators who do not have sufficient proficiency in the language of the study (if applicable).
- Educators who have conflicts of interest that may bias their responses or recommendations.

RESULTS

SEM (structural equation modelling)

Structural Equation Modeling (SEM), a flexible statistical approach, to describe complex interactions between variables, whether latent or observable. Its ability to analyse intricate causal pathways, integrate latent components, test several hypotheses at once, account for measurement error, evaluate model fit, and combine aspects of factor analysis and regression are just a few of its special features. SEM is an essential tool for research in disciplines like psychology, sociology, economics, and beyond because it can be used to validate theoretical models, examine the



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effects of interventions or policies, and simplify complex datasets. This allows for more thorough and accurate data analysis and hypothesis testing.

Measurement model and validity

Measurement models and validity are indispensable in research as they establish a structured framework for ensuring the accuracy and meaningfulness of data. Measurement models clarify the relationships between observed variables and their underlying constructs, enabling researchers to assess complex concepts. Validity, on the other hand, ensures that the measurement instruments precisely capture the intended constructs, safeguarding against misleading or incorrect conclusions. Both measurement models and validity are essential components in research, serving as the foundation for reliable and credible findings, which is paramount for informed decision-making and advancing knowledge across diverse field. In order to do the confirmatory factor analysis, the sample size was adequate and suitable, as indicated in the table above, where the value of KMO was 0.935. We also made sure that the variables used in confirmatory factor analysis were significantly correlated at the 0.00 level of confidence by using Bartlett's Test of Sphericity. We used CFA, or Confirmatory Factor Analysis, to check our instrument's validity thoroughly. The factor loadings for each individual question exceeded the 0.5 threshold, underscoring the instrument's strong capability to accurately measure the intended constructs. This outcome underscores the robustness of our measurement tool. Since the factor loading value is less than 0.6, several items are omitted from the subsequent analysis. The variables "Challenges in Implementation" and "CI4" are eliminated. Table 18 displays the model fit values. To ascertain the internal consistency of the scale, We computed the Composite Reliability (CR) and Average Variance Extracted (AVE). For your perusal, Table 16 displays the results of the post-CFA study. in addition to which are the CR, AVE, and Cronbach's alpha values. When one variable's square root of its AVE is larger than its correction values when compared to other variables, discriminant validity is established. The findings that were collected are shown in Table 17, and they contribute to the determination of the discriminant validity.

Discriminant validity test

Discriminant validity is not a specific test performed in SPSS or any other statistical software but a concept within the context of validating measurement instruments and assessing the relationships between variables. Discriminant validity is crucial to ensure that different constructs or variables in a study are truly distinct and not measuring the same underlying concept. Researchers use various techniques such as confirmatory factor analysis (CFA) or correlation analysis to demonstrate that the measures intended to assess different constructs are, indeed, different and not highly correlated. Discriminant validity helps ensure that the measurement instruments accurately represent the unique concepts they are meant to measure, preventing construct overlap or redundancy and allowing for more robust and accurate data analysis and interpretation. In the discriminant validity test, the relationships between various constructs related to gamification in education are investigated. These constructs include the level of gamification, the level of student engagement, perceptions of gamification, inclusive learning outcomes, recommendations for effective implementation, and challenges in implementation.

Coefficients of correlation are also displayed in the table, and The square roots of each construct's average variance extracted (AVE) are reflected in the diagonal numbers. We can see the interrelationships between the concepts in the non-diagonal numbers. The data indicate that there are significant positive relationships between the amount of gamification and student engagement (.837), perceptions of gamification (.708), and inclusive learning outcomes (.688). Similar to the previous point, there are significant positive relationships between student involvement and views of gamification (.772), inclusive learning outcomes (.747), and suggestions for successful implementation (.692). Furthermore, there is a substantial correlation between views of gamification and inclusive learning results (.822) as well as suggestions for successful implementation (.781). Furthermore, there is a significant positive connection between the results of inclusive learning and the suggestions for successful implementation (.793). On the other hand, the correlations between difficulties in implementation and other kinds of constructs are quite low, which suggests that there is the possibility of discriminant validity. Despite the fact that gamification level, student engagement, perceptions of gamification, inclusive learning outcomes, and recommendations for effective implementation are all closely related to one another, these results suggest that these constructs are distinct from one another, implying that



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each contributes in its own unique way to the overall understanding of gamification in educational contexts. With $\chi^2 = 577.275$, the fit quality was satisfactory in representing the sample data. NFI (Normed Fit Index) = 0.914; IFI (Incremental fit index) = 0.966, GFI (Goodness of Fit) = 0.908, RFI (Relative Fit Index) = 0.900 and CFI (Comparative Fit Index) = 0.965 which is much larger than the 0.90. Similarly, RMR (Root Mean Square Residuals) = 0.042 and RMSEA (Root mean square error of approximation) = 0.040 values are lower the 0.080 critical value. With an RMSEA of 0.040, RMR of 0.042, GFI of 0.908, and CFI of 0.965, the results showed that the given model was a good fit.

Proposed Hypothesis

H1: Gamification level in educational interventions will positively influence student engagement in an inclusive classroom. In this hypothetical structural equation model, the table shows how two variables—the degree of gamification and student engagement—are dependent on one another. Here, the degree of gamification serves as the independent variable, with student engagement serving as the dependent variable. A favorable and statistically significant correlation between Transparent and Equitable and Faculty Performance was found in the analysis. ($\beta = .786$, $P < 0.05$). The standardized coefficient of 0.786, a positive association between Gamification level and Student Engagement, as shown in the route connecting these two variables. The correlation coefficient values (C.R. values) show large magnitudes, suggesting that the observed associations are statistically significant. According to the fit indices shown in Table 20, The data and the model are well-aligned. Thus, seven separate fit indices were used to assess the overall model fit; these indices showed a positive and statistically significant correlation between the degree of gamification and student engagement. With a χ^2 value of 30.262, the fit quality was satisfactory in representing the sample data. NFI (Normed Fit Index) = 0.982; IFI (Incremental fit index) = 0.999, GFI (Goodness of Fit) = 0.985, RFI (Relative Fit Index) = 0.972 and CFI (Comparative Fit Index) = 0.999 which is much larger than the 0.90. Similarly, RMR (Root Mean Square Residuals) = 0.020 and RMSEA (Root mean square error of approximation) = 0.011 values are lower the 0.080 critical value. With an RMSEA of 0.011, RMR of 0.020, GFI of 0.985, and CFI of 0.999, the results showed that the displayed model was an excellent fit.

H2: The relationship between gamification level and student engagement will be mediated by challenges in implementation. In the default regression model for Group number 1, the relationships between various factors affecting implementation challenges, gamification level, and student engagement are examined. The unstandardized estimates show the strength and direction of these relationships. Specifically, a higher gamification level is associated with increased challenges in implementation, as indicated by a positive unstandardized estimate of .598. Furthermore, student engagement is positively influenced by both challenges in implementation and gamification level, with unstandardized estimates of .493 and .568, respectively. The p-values and critical ratios (C.R.) for these associations show that they are statistically significant, emphasizing the importance of addressing implementation challenges and leveraging gamification strategies to enhance student engagement. In the default model of Group number 1, standardized indirect effects were analysed between gamification level and challenges in implementation, as well as between student engagement and challenges in implementation. With an RMSEA of 0.011, RMR of 0.020, GFI of 0.985, and CFI of 0.999, the results showed that the displayed model was an excellent fit, suggesting that higher levels of student engagement are associated with increased challenges in implementation. However, there is no significant indirect effect observed between gamification level and challenges in implementation, as the coefficient for this relationship is .000. These findings suggest that while student engagement may contribute to challenges in implementation, the level of gamification does not have a direct impact on implementation challenges in this particular model.

H3: The relationship between gamification level and student engagement will be moderated by educators' perceptions, such that the impact of gamification on student engagement will be stronger when educators have positive perceptions of gamified interventions.

Our model is the Structural Equation Model (SEM), which looks at how Zscore(STUDENT_ENGAGEMENT) and Zscore(Gamification_Level), with moderation by Perceptions_of_Gamification is presented in Table 1. Taking into account measurement errors and feedback directly within the model, this all-encompassing approach permits testing of all important paths.



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Path analysis-based hypothesis testing reveals that Zscore(Gamification_Level) is positively and significantly associated with Zscore(STUDENT_ENGAGEMENT) ($\beta=.406$, $P<0.05$). Gender is negatively and significantly associated with Zscore(STUDENT_ENGAGEMENT) ($\beta=-.342$, $P<0.05$).

Moderation Testing

In order to perform the moderation analysis, dealing with Zscore(Gamification_Level) as independent variables, Zscore(STUDENT_ENGAGEMENT) as dependent variable, and Moderation variables (Perceptions_of_Gamification) as moderator variable. To get the numbers, we use SPSS to make interaction terms out of the standardized scores of the variables. We tested the Perceptions_of_Gamification as a moderator. According to the results, the interaction term of Zscore(Gamification_Level) and Zscore (Perceptions_of_Gamification) has a notable and beneficial impact on Zscore(STUDENT_ENGAGEMENT) ($\beta= 0.180$, $P<0.05$). The findings provide statistical proof that demographic variables influence the relationship, which goes against the expected association's nature. There are significant factors with $p>0.05$, and the model's fit indices show that it fits the data well. (as shown in Table 2). To determine whether the proposed model was consistent with the data, we used a number of global fit indices and the significance level, or 'r', to measure the model's fit. According to the data in the table above, the relationship between Gamification_Level and STUDENT_ENGAGEMENT is moderated by (Perceptions_of_Gamification).

Recommendations

Educators should tailor gamified interventions to accommodate diverse learning needs and abilities in an inclusive classroom. This can include adjusting difficulty levels, providing multiple pathways to success, and offering various modes of interaction. Integrating Universal Design for Learning principles into gamified educational interventions can enhance accessibility and inclusivity. Collaborative learning opportunities should be encouraged within gamified interventions to foster peer interaction and support. Clear communication and instruction should be provided, using visual aids, verbal explanations, and written instructions to accommodate different learning preferences. Effective feedback mechanisms should be implemented to provide timely and constructive feedback to students. A variety of assessment strategies, including formative assessments, self-assessments, and peer evaluations, should be used to monitor progress and provide opportunities for reflection and improvement. Flexibility and differentiation should be maintained in gamified interventions to accommodate individual learning paces and preferences. Offer options for students to choose activities or challenges based on their interests, strengths, and areas for growth. Professional development and training opportunities should be provided for educators to enhance their knowledge and skills in implementing gamified interventions in inclusive classrooms. Continuous evaluation and reflection should be conducted to identify areas for improvement and refine gamified activities to better meet the needs of all learners. Community engagement and support should be fostered among educators, parents, and community stakeholders to promote the successful implementation of gamified interventions in inclusive classrooms. Ethical considerations and equity should be ensured, ensuring that gamified interventions uphold ethical standards and promote equity and social justice.

CONCLUSION

Contributing to our understanding of gamified educational interventions that employ inclusive classrooms are the results of this study. This underscores the need of overcoming problems in implementation and taking into consideration the perspectives of educators in order to improve the success of gamification tactics. According to the findings, gamification appears to have a beneficial impact on student engagement, with difficulties in implementation serving as a moderating factor and the perceptions of educators serving as a mediating factor. It is possible for educators and policymakers to build educational solutions that are more successful and inclusive if they acknowledge these aspects. In the long run, this will help students succeed academically and foster a supportive classroom atmosphere. Gamification in education is a complex phenomenon that necessitates ongoing research into its dynamics, taking into account a wide range of contextual elements and investigating its long-term impacts on students' learning and development.





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Table 1: Regression Weights: (Group number 1 - Default model)

Path	Unstandardized Estimate	S.E.	Standardized Estimates	C.R.	P
CI5 <--- Challenges in Implementation	1.000		.673		
CI3 <--- Challenges in Implementation	1.056	.083	.699	12.651	***
CI2 <--- Challenges in Implementation	.803	.071	.629	11.256	***
CI1 <--- Challenges in Implementation	1.017	.084	.708	12.141	***
GL5 <--- Gamification Level	1.000		.639		
GL4 <--- Gamification Level	.991	.086	.632	11.556	***
GL3 <--- Gamification Level	1.117	.088	.674	12.662	***
GL2 <--- Gamification Level	1.215	.109	.749	11.162	***
GL1 <--- Gamification Level	1.329	.109	.816	12.199	***
REI5 <--- Recommendations for Effective Implementation	1.000		.666		
REI4 <--- Recommendations for Effective Implementation	.893	.083	.609	10.699	***
REI3 <--- Recommendations for Effective Implementation	.971	.073	.634	13.293	***
REI2 <--- Recommendations for Effective Implementation	1.147	.088	.763	13.034	***
REI1 <--- Recommendations for Effective Implementation	1.470	.100	.849	14.665	***
PG5 <--- Perceptions of Gamification	1.000		.666		
PG4 <--- Perceptions of Gamification	1.118	.089	.701	12.549	***
PG3 <--- Perceptions of Gamification	1.158	.077	.762	15.000	***
PG2 <--- Perceptions of Gamification	1.127	.089	.790	12.649	***
PG1 <--- Perceptions of Gamification	1.619	.108	.839	15.036	***
SE5 <--- Student Engagement	1.000		.624		
SE4 <--- Student Engagement	1.116	.119	.667	9.353	***
SE3 <--- Student Engagement	1.163	.106	.688	10.989	***
SE2 <--- Student Engagement	1.037	.115	.653	9.048	***
SE1 <--- Student Engagement	1.523	.135	.800	11.291	***
ILO6 <--- Inclusive Learning Outcomes	1.000		.661		
ILO5 <--- Inclusive Learning Outcomes	.995	.099	.672	10.083	***
ILO4 <--- Inclusive Learning Outcomes	1.149	.085	.737	13.573	***
ILO3 <--- Inclusive Learning Outcomes	1.206	.097	.769	12.400	***
ILO2 <--- Inclusive Learning Outcomes	1.438	.109	.858	13.225	***





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Path	Unstandardized Estimate	S.E.	Standardized Estimates	C.R.	P
ILO1 <--- Inclusive Learning Outcomes	1.453	.130	.700	11.159	***

Table 2: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.935
Bartlett's Test of Sphericity	Approx. Chi-Square	6544.594
	df	435
	Sig.	.000

Table 3: Post CFA, Cronbach alpha, factor loadings

Factors and items	Cronbach alpha values	Post CFA factor loadings	AVE	CR
Gamification Level	.850		0.702	0.837
GL1		.816		
GL2		.749		
GL3		.674		
GL4		.632		
GL5		.639		
Perceptions of Gamification	.872		0.751	0.855
PG1		.839		
PG2		.790		
PG3		.762		
PG4		.701		
PG5		.666		
Challenges in Implementation	.770		0.677	0.782
CI1		.708		
CI2		.629		
CI3		.699		
CI5		.673		
Recommendations for Effective Implementation	.854		0.704	0.838
REI1		.849		
REI2		.763		
REI3		.634		
REI4		.609		
REI5		.666		
Student Engagement	.836		0.686	0.831
SE1		.800		
SE2		.653		
SE3		.688		
SE4		.667		
SE5		.624		
Inclusive Learning Outcomes	.867		0.732	0.850
ILO1		.700		
ILO2		.858		
ILO3		.769		





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ILO4		.737		
ILO5		.672		
ILO6		.661		

Table 4: Discriminant validity Test

	Gamification Level	Student Engagement	Perceptions Of Gamification	Inclusive Learning Outcomes	Recommendations For Effective Implementation	Challenges In Implementation
Gamification Level	0.837854403					
Student Engagement	.772**	0.866602562				
Perceptions Of Gamification	.708**	.781**	0.822800097			
Inclusive Learning Outcomes	.688**	.747**	.839**	0.839047079		
Recommendations For Effective Implementation	.682**	.692**	.793**	.772**	0.82825117	
Challenges In Implementation	.660**	.736**	.841**	.969**	.752**	0.855569985

Table 5: Model fit summary

Variable	Value
Chi-square value(χ^2)	577.275
Degrees of freedom (df)	358
CMIN/DF	1.612
P value	0.062
GFI	0.908
RFI	0.900
NFI	0.914
IFI	0.966
CFI	0.965
RMR	0.042
RMSEA	0.040

Table 6: Regression Weights: (Group number 1 - Default model)

Path	Unstandardized Estimate	S.E.	Standardized Estimates	C.R.	P
Student Engagement <--- Gamification level	.940	.085	.786	11.104	***
GL5 <--- Gamification level	1.000		.720		





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Path			Unstandardized Estimate	S.E.	Standardized Estimates	C.R.	P
GL4	<---	Gamification level	.984	.079	.706	12.526	***
GL3	<---	Gamification level	1.137	.083	.773	13.725	***
GL2	<---	Gamification level	1.000	.081	.694	12.313	***
GL1	<---	Gamification level	1.036	.081	.717	12.822	***
SE1	<---	Student Engagement	1.000		.762		
SE2	<---	Student Engagement	.746	.062	.679	12.039	***
SE3	<---	Student Engagement	.831	.064	.712	12.888	***
SE4	<---	Student Engagement	.789	.065	.685	12.150	***
SE5	<---	Student Engagement	.772	.065	.701	11.796	***

Table 7: Model fit summary

Variable	Value
Chi-square value(χ^2)	30.262
Degrees of freedom (df)	29
CMIN/DF	1.044
P value	0.401
GFI	0.985
RFI	0.972
NFI	0.982
IFI	0.999
CFI	0.999
RMR	0.020
RMSEA	0.011

Table 8: Regression Weights: (Group number 1 - Default model)

Path			Unstandardized Estimate	S.E.	Standardized Estimates	C.R.	P
Challenges in Implementation	<---	Gamification Level	.598	.035	.660	17.174	***
Student Engagement	<---	Challenges in Implementation	.493	.047	.400	10.523	***
Student Engagement	<---	Gamification Level	.568	.042	.509	13.376	***





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Table 9: Standardized Indirect Effects (Group number 1 - Default model)

	Gamification Level	Challenges in Implementation
Challenges in Implementation	.000	.000
Student Engagement	.264	.000

Table 10: Regression Weights: (Group number 1 - Default model)

Path		Unstandardized Estimate	S. E.	Standardized Estimates	C.R.	P
ZSTUDENT_ENGAGEMENT	<-- ZGamification_Level	.406	.040	.406	10.211	***
ZSTUDENT_ENGAGEMENT	<-- ZPerceptions_of_Gamification	.342	.053	.342	6.442	***
ZSTUDENT_ENGAGEMENT	<-- ZGamification_Level*ZPerceptions_of_Gamification	.180	.052	.180	3.496	***

Table 11: Regression Weights: (Group number 1 - Default model)

Path		Unstandardized Estimate	S. E.	Standardized Estimates	C.R.	P
ZSTUDENT_ENGAGEMENT	<-- ZGamification_Level*ZPerceptions_of_Gamification	.180	.052	.180	3.496	**

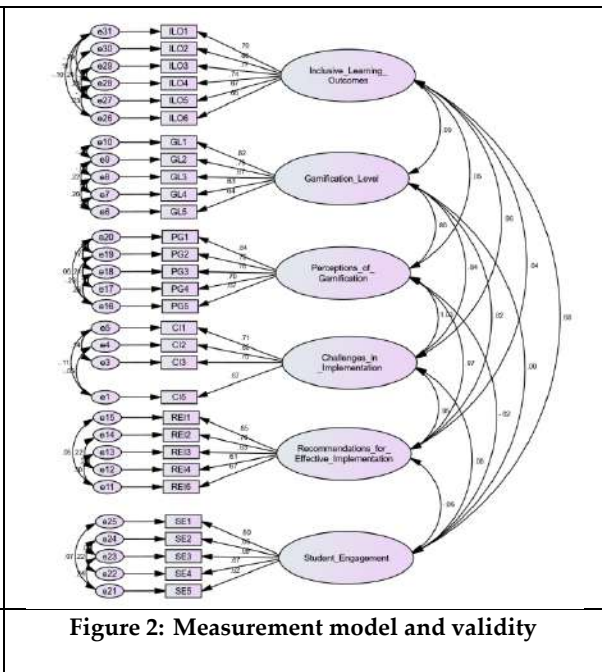
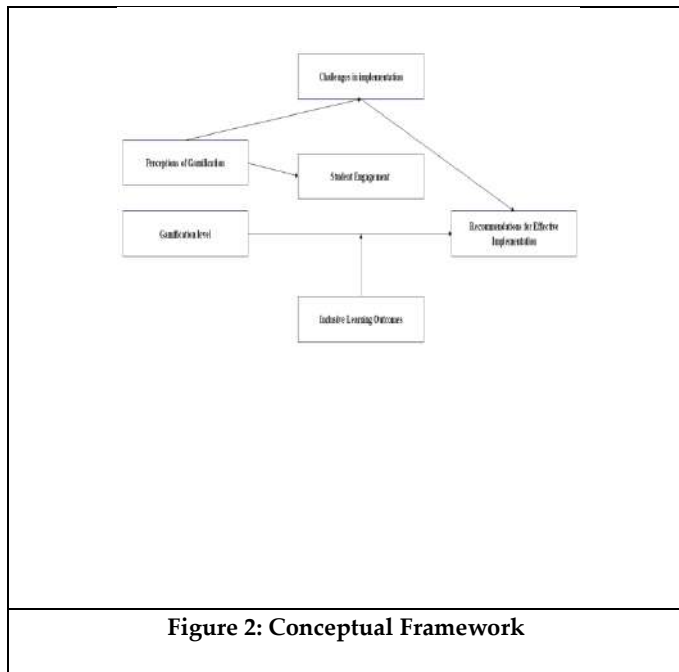


Figure 2: Conceptual Framework

Figure 2: Measurement model and validity





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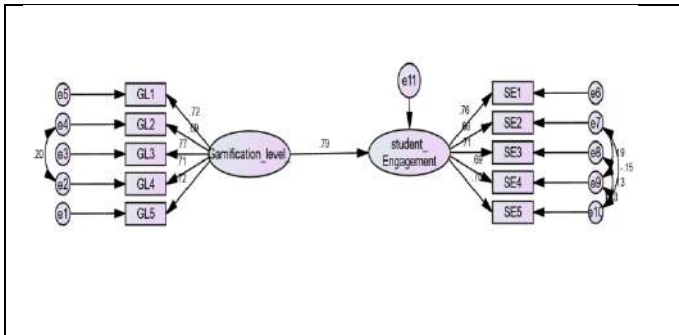


Figure 3: Proposed Hypothesis

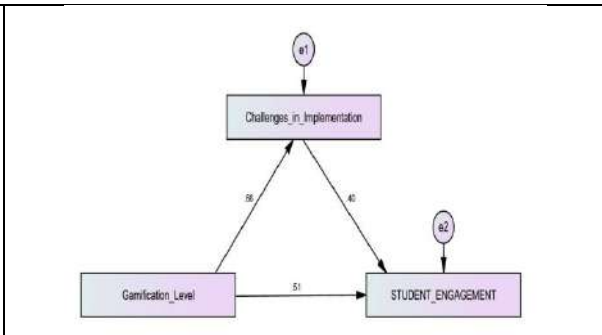


Figure 4: Implementation

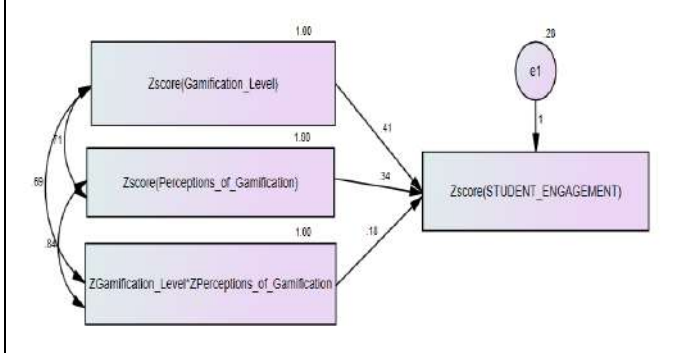


Figure 5: Relationship

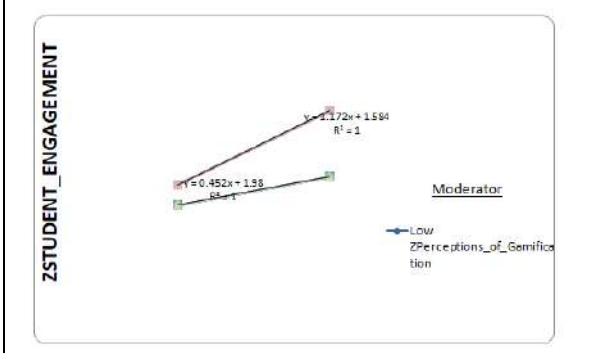


Figure 6: Moderator





Knowledge, Attitude and Practice of Infection, Prevention and Control Precautions among Undergraduate Pharmacist Students in South India

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ABSTRACT

This review examines the knowledge, attitude, and practice (KAP) of infection prevention and control (IPC) among undergraduate pharmacy students in South India, highlighting the significance of IPC in healthcare and the pivotal role of pharmacy students in this domain. The review delves into the current educational frameworks within pharmacy curricula in South India, assessing the integration of IPC training and its practical application. It identifies challenges such as resource limitations, curriculum constraints, and cultural aspects that affect IPC learning and implementation. Through a comparative analysis, the study provides insights into how IPC KAP among pharmacy students in South India stands in relation to their global counterparts, underscoring the influence of diverse educational and healthcare contexts. The review emphasizes the critical impact of effective IPC training on patient care and infection control, advocating for enhanced educational strategies and policy support to improve IPC practices. Recommendations for future research and educational innovations are presented, including the integration of emerging technologies and interactive teaching methods to enrich IPC education. This comprehensive analysis aims to contribute to the advancement of IPC competencies among future pharmacists, ultimately fostering improved healthcare outcomes and public health.

Keywords: Infection Prevention and Control, Pharmacy Education, South India, Knowledge, Attitude, and Practice, Healthcare Outcomes.





INTRODUCTION

Infection prevention and control (IPC) is a critical aspect of healthcare that aims to prevent or reduce the incidence of healthcare-associated infections (HAIs) among patients and healthcare workers. The significance of IPC in healthcare settings is underscored by its direct impact on patient safety, treatment outcomes, and overall healthcare costs(1,2). Effective IPC measures, such as hand hygiene, the use of personal protective equipment (PPE), sterilization of medical equipment, and isolation protocols, are essential to prevent the transmission of infectious pathogens within healthcare facilities(3,4). The implications of inadequate IPC practices are profound, ranging from increased morbidity and mortality to extended hospital stays and heightened financial burdens on healthcare systems(5). For instance, HAIs can lead to severe complications, including bloodstream infections, surgical site infections, and pneumonia, which can be life-threatening if not addressed promptly and effectively. Moreover, the emergence of antibiotic-resistant bacteria has made the implementation of robust IPC strategies more crucial than ever(6-8). IPC is not only about preventing infection but also about fostering a culture of safety that permeates all levels of healthcare delivery. It involves a comprehensive approach that includes surveillance, reporting, and analysis of infection data, education and training of healthcare personnel, and adherence to evidence-based practices. Through these concerted efforts, healthcare settings can create a safer environment for both patients and healthcare professionals, ultimately enhancing the quality of care and patient outcomes(9). The objectives of a review focusing on the knowledge, attitude, and practice (KAP) of infection prevention and control (IPC) among undergraduate pharmacy students in South India are multifaceted and aim to comprehensively understand the current landscape, identify gaps, and suggest improvements in education and practice.

Assess the Current Level of Knowledge

One primary objective is to assess the current level of knowledge that undergraduate pharmacy students in South India possess regarding IPC. This involves understanding what students know about various IPC protocols, guidelines, and the rationale behind them. The review would aim to identify specific areas where knowledge is strong and areas where there may be significant gaps or misconceptions.

Evaluate Attitudes Towards IPC

Another critical objective is to evaluate the attitudes of pharmacy students toward IPC practices. This includes understanding how students perceive the importance of IPC in their future professional roles, their willingness to comply with IPC guidelines, and their perception of the impact of IPC on patient safety and healthcare outcomes. Attitudes can significantly influence the implementation of knowledge into practice, making this a crucial area of investigation.

Analyze Practice Behaviours

The review also aims to analyze the actual practice behaviors of pharmacy students regarding IPC. This involves investigating how well students apply their knowledge of IPC in clinical settings or simulations, their adherence to IPC guidelines during their training, and any barriers they face in implementing best practices.

Identify Educational Gaps and Needs

By synthesizing information on knowledge, attitudes, and practices, the review intends to identify educational gaps and needs within the pharmacy curriculum. It aims to pinpoint areas where additional training or emphasis could enhance IPC understanding and implementation among students.

Inform Policy and Curriculum Development

An essential objective of the review is to provide evidence-based recommendations that can inform policy and curriculum development. By identifying the strengths and weaknesses in current IPC education for pharmacy students, the review can suggest targeted interventions to improve IPC knowledge, attitudes, and practices. This





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could involve recommendations for curriculum enhancement, teaching methodologies, and student assessment strategies.

Contribute to Improved Healthcare Outcomes

Ultimately, the review aims to contribute to improved healthcare outcomes by enhancing the IPC competence of future pharmacists. By ensuring that pharmacy students in South India are well-equipped with the necessary IPC knowledge, attitudes, and skills, they can play a pivotal role in preventing infections, improving patient safety, and reducing the burden of healthcare-associated infections(10).

Pharmacy Students' Role in IPC and the Significance

Pharmacy students are integral to the healthcare team, and their role in IPC extends beyond the pharmacy's confines to the broader healthcare setting. As future pharmacists, they are positioned to influence IPC practices through various avenues, including medication management, patient education, and participation in multidisciplinary teams. Their education in IPC is crucial, as it lays the foundation for their understanding of how infectious diseases are transmitted and controlled, the importance of antimicrobial stewardship, and the impact of their actions on the health and safety of patients and colleagues. Pharmacy students learn to apply IPC principles in diverse settings, from community pharmacies to hospital wards, where they can advocate for and adhere to best practices in infection control. They are trained to provide advice on the proper use of antibiotics, educate patients on hygiene practices, and ensure the aseptic handling of medications. Their role in promoting vaccination, managing isolation precautions, and contributing to the development and implementation of IPC policies further underscores their importance in this field. The education of pharmacy students in IPC is significant not only for their professional development but also for the broader goal of enhancing healthcare quality and patient safety. By embedding IPC principles in pharmacy education, students are equipped with the knowledge and skills necessary to become champions of infection control, whether through direct patient care, participation in infection control committees, or through research and advocacy(11).

Rationale for Focusing on South India

Focusing on South India for a study on IPC among pharmacy students is justified by several region-specific factors. South India, with its dense population, diverse healthcare settings, and varying levels of healthcare access and quality, presents a unique environment for examining IPC practices. The region's healthcare system is a mix of urban and rural settings, with differences in healthcare infrastructure, which can influence IPC practices and outcomes. Moreover, South India has a significant number of pharmacy colleges and a large population of pharmacy students, making it an ideal setting for studying educational practices and their impacts on IPC. The region's diverse socio-cultural context also plays a role in shaping attitudes and practices related to health and hygiene, which are crucial components of effective IPC. Investigating IPC practices in South India can provide insights into the challenges and opportunities in pharmacy education and healthcare delivery in the region. It can also contribute to developing tailored IPC strategies that address the specific needs and constraints of South India. By focusing on this region, researchers can generate evidence that informs policy and practice, ultimately improving infection control measures and healthcare outcomes in South India and potentially serving as a model for other regions with similar contexts.

METHODOLOGY

The search strategy for the review aims to comprehensively capture literature related to the knowledge, attitude, and practice (KAP) of infection prevention and control (IPC) among undergraduate pharmacy students in South India. To achieve this, a meticulous approach involving various databases and specific keywords, alongside defined inclusion and exclusion criteria, is employed.





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Databases

The search will encompass several databases to ensure a broad and diverse collection of relevant literature. These may include PubMed, Scopus, Web of Science, and Google Scholar, among others. Each database offers a unique range of journals and publications, enhancing the comprehensiveness of the search.

Keywords

A combination of keywords will be used to capture all relevant literature. These might include "infection prevention and control," "knowledge," "attitude," "practice," "pharmacy students," "South India," and "undergraduate education." Boolean operators (AND, OR) will be utilized to refine the search, e.g., "infection prevention and control AND pharmacy students AND South India."

Inclusion and Exclusion Criteria

The inclusion criteria might consist of studies focusing on undergraduate pharmacy students, studies conducted in South India, and publications within the last decade to ensure relevance. Exclusion criteria could include non-English publications, studies not specifically addressing IPC, or research focusing on postgraduates or professionals outside the pharmacy discipline.

Approach to Selecting and Analysing the Relevant Literature

Selection Process

Initially, titles and abstracts will be screened based on the inclusion and exclusion criteria. Subsequently, full-text articles will be reviewed for detailed analysis. This two-step process ensures that only pertinent studies are considered for review.

Analysing Literature

Each selected study will be critically analyzed to extract data on the knowledge, attitudes, and practices regarding IPC among pharmacy students. This analysis will consider the study design, sample size, methodology, key findings, and limitations. The critical appraisal will help in understanding the robustness and applicability of the findings.

Organization

The literature will be organized thematically or methodologically, depending on the nature and diversity of the findings. This organization aids in identifying patterns, trends, and gaps in the existing research(12).

Method for Synthesizing the Findings

Synthesis Approach

The synthesis of findings will be approached through a narrative synthesis or a thematic analysis, depending on the nature of the collected data. This involves summarizing and explaining the findings across the selected studies, identifying common themes, and noting any significant variances or contradictions.

Thematic Analysis

If a thematic analysis is chosen, the data will be categorized into themes such as knowledge gaps, attitudes towards IPC, and observed practices. This approach allows for a nuanced understanding of the various dimensions of the KAP related to IPC.

Integration of Quantitative and Qualitative Data

In cases where the review includes both quantitative and qualitative studies, a mixed-methods synthesis will be employed. This will involve integrating quantitative data on prevalence and statistical correlations with qualitative insights into student perceptions and experiences.





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Drawing Conclusions

The synthesis will aim to draw evidence-based conclusions regarding the current state of IPC KAP among pharmacy students in South India. It will identify patterns, assess the quality of the evidence, and consider the implications of the findings for education, practice, and policy.

Recommendations for Future Research

Based on the synthesis, the review will highlight areas where further research is needed, pointing out any significant gaps or inconsistencies in the existing literature(13).

Current Knowledge, Attitudes, and Practices

Knowledge Levels of Pharmacy Students in South India Regarding IPC

Research on the knowledge levels of pharmacy students in South India often reveals a spectrum of understanding regarding IPC. Studies typically evaluate students' familiarity with IPC guidelines, their understanding of the modes of transmission of infectious diseases, and their knowledge of the measures necessary to prevent these infections. Results might show that while students have a foundational understanding of basic IPC principles, there can be significant gaps in their knowledge about specific protocols, such as the correct use of personal protective equipment (PPE), hand hygiene techniques, and the latest guidelines on infection control. Moreover, the depth of IPC knowledge could vary based on the year of study, with senior students demonstrating a higher level of understanding compared to their junior counterparts. This gradient in knowledge suggests an ongoing learning process but also highlights the need for early and consistent integration of IPC topics throughout the pharmacy curriculum. The research might also indicate a disparity in knowledge between students from different institutions, pointing towards variability in the emphasis on IPC in pharmacy education across South India. Such studies underscore the importance of a standardized IPC curriculum to ensure that all pharmacy students acquire the necessary knowledge to safeguard patient health and prevent the spread of infections in healthcare settings(14).

Attitudes Towards IPC Among Pharmacy Students

Studies assessing attitudes towards IPC among pharmacy students in South India would likely explore students' perceptions of the importance of IPC, their willingness to adhere to IPC guidelines, and their sense of responsibility in preventing infections. The findings might reveal a generally positive attitude toward IPC, with students recognizing its critical role in healthcare and patient safety. However, research might also uncover challenges such as complacency, perceived barriers to IPC adherence (such as time constraints or resource limitations), and a possible underestimation of the role of pharmacists in infection control. Some studies could highlight the influence of cultural factors and educational background on students' attitudes, indicating that while students value IPC, they may not always perceive it as a direct component of their future professional practice. Enhancing positive attitudes toward IPC would involve not only education but also role modelling by faculty and exposure to real-world scenarios where IPC is crucial. This would help bridge the gap between theoretical knowledge and practical implementation, fostering a culture of infection prevention that aligns with global healthcare standards(15).

IPC Practices Adopted by Pharmacy Students

Reviewing the actual IPC practices adopted by pharmacy students in South India would involve examining how students apply their knowledge in practical settings, such as during clinical rotations or in simulation labs. Findings might show a discrepancy between theoretical knowledge and practice, with students sometimes failing to adhere to IPC measures due to lack of confidence, oversight, or understanding of the real-world implications of these practices. Observations might include inconsistent hand hygiene, improper use or disposal of PPE, and inadequate sterilization techniques. Such studies could also assess the impact of educational interventions, like workshops or hands-on training, in improving IPC practices among students. The research could emphasize the need for more experiential learning opportunities where students can apply IPC knowledge in controlled, supervised environments. This hands-





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on experience is crucial for students to understand the practical importance of IPC measures, ultimately leading to better adherence in their professional lives.

By exploring these three areas, research provides a holistic view of the IPC preparedness of pharmacy students in South India, offering insights into how education can be enhanced to promote better infection control practices in future healthcare professionals(16,17).

Educational Framework and Curriculum Analysis:

Examination of IPC-related Content within Pharmacy Curricula in South Indian Institutions

A thorough examination of the IPC-related content within pharmacy curricula in South Indian institutions would involve a detailed analysis of course syllabi, teaching methods, and educational materials to identify the extent and depth of IPC coverage. This evaluation aims to understand how well the curricula prepare pharmacy students for the critical role of infection prevention and control in healthcare settings. Typically, this analysis would reveal the presence of dedicated IPC modules or the integration of IPC topics across various subjects. Key areas of focus might include the principles of microbiology, modes of infection transmission, standard precautions, use of personal protective equipment, and antimicrobial stewardship. However, the depth of coverage could vary, with some institutions offering comprehensive, in-depth discussions on IPC, while others may only touch on these topics superficially. The evaluation might also consider the pedagogical approaches used to teach IPC, such as lectures, seminars, workshops, and hands-on training. The presence of interdisciplinary learning experiences, which expose students to IPC practices in real-world healthcare settings, could also be a focal point. Additionally, the assessment would look at how current and evidence-based the IPC content is, ensuring that students are being taught the most up-to-date practices(18).

Assessment of How IPC Training is Integrated into Pharmacy Education and Practical Training

Assessing the integration of IPC training into pharmacy education and practical training involves looking beyond the curriculum to understand how theoretical knowledge is applied in practical settings. This includes evaluating clinical rotations, laboratory work, and other experiential learning opportunities where students can engage in IPC practices. In ideal scenarios, IPC training should not be confined to the classroom but extensively incorporated into practical training sessions. This might involve simulated exercises, role-playing scenarios, or clinical placements where students can observe and participate in IPC measures firsthand. The assessment would explore whether students receive consistent feedback and reinforcement of IPC practices during these activities and if they have opportunities to reflect on and improve their IPC skills. Another critical aspect is the collaboration with other healthcare disciplines in IPC training, promoting a multidisciplinary approach that reflects real-world healthcare settings. Assessing how pharmacy students interact with nursing, medical, and other health science students in joint IPC exercises can provide insights into their readiness for collaborative practice in infection control(19).

Challenges and Barriers

Challenges and Barriers in Acquiring and Applying IPC Knowledge

Pharmacy students often face a myriad of challenges and barriers in acquiring and applying IPC knowledge effectively. One primary challenge is the complexity and breadth of IPC itself, which requires a deep understanding of microbiology, epidemiology, clinical practices, and behavioural sciences. Students may find it challenging to integrate this multidisciplinary knowledge into a cohesive framework for practical application. Moreover, the translation of theoretical knowledge into practice is a significant hurdle. Many students have limited opportunities to engage in hands-on IPC activities or to observe these practices in clinical settings before they enter the workforce. This lack of practical exposure can lead to a gap between what students know and how they apply this knowledge in real-world settings. There's also the challenge of keeping abreast with the rapidly evolving field of IPC, especially with the emergence of new pathogens and resistance mechanisms. Students may find it challenging to stay updated with the latest guidelines and research, particularly if the curriculum is not regularly updated(20).





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Resource Limitations, Curriculum Constraints, and Cultural Aspects

Resource Limitations

Many educational institutions in South India may face resource constraints that affect IPC training. This can include limited access to modern laboratory facilities, insufficient teaching materials, or a shortage of faculty with expertise in IPC. Such limitations can hinder the provision of comprehensive and hands-on IPC education, impacting students' learning experiences and outcomes.

Curriculum Constraints

The pharmacy curriculum is often packed with a wide range of subjects, and IPC might not receive the emphasis it requires. There may be a lack of dedicated IPC courses, or the topic may be scattered across various subjects without a coordinated approach. This fragmentation can lead to students not fully appreciating the centrality of IPC in their future professional roles.

Cultural Aspects

Cultural factors can also influence how IPC is perceived and practiced by pharmacy students. For example, attitudes toward hygiene, infection risk, and compliance with IPC measures can vary widely and be influenced by societal norms and beliefs. Furthermore, the hierarchical nature of healthcare settings in South India may deter students from voicing concerns or taking initiative in IPC-related matters, especially when it contradicts the practices of more senior healthcare providers(21).

Comparative Analysis

Comparison of IPC KAP Among Pharmacy Students in South India with Other Regions or Countries:

A comparative analysis of IPC knowledge, attitudes, and practices (KAP) among pharmacy students in South India versus their counterparts in other regions or countries can reveal significant insights. This comparison often involves evaluating the curriculum, the depth of knowledge, the prevailing attitudes towards IPC, and the practical application of IPC principles in various settings. For instance, pharmacy students in South India may have a different level of IPC knowledge compared to students in Western countries, where IPC protocols might be more rigorously integrated into healthcare systems. The comparison could show that students in more developed healthcare settings possess a more advanced understanding of IPC due to greater access to resources, advanced training simulations, and exposure to diverse clinical environments. On the other hand, pharmacy students in South India might exhibit certain strengths, such as adaptability and innovation in IPC practices, driven by resource constraints and unique healthcare challenges. These comparative analyses can shed light on how different educational, healthcare, and socio-economic contexts influence IPC KAP among pharmacy students.

Highlighting Differences and Discussing Potential Reasons

The differences in IPC KAP among pharmacy students across different regions can be attributed to several factors: Curriculum and Education: The structure and content of pharmacy education can vary widely, influencing how well students are prepared in IPC. Regions where the curriculum emphasizes practical IPC training might produce students with a more profound practical understanding of infection control. Resource Availability: Access to modern educational resources, including simulation labs and clinical training sites, can enhance IPC learning experiences, leading to better KAP outcomes among students.

Cultural Influences

Cultural attitudes towards hygiene, disease prevention, and healthcare practices can impact students' attitudes and practices related to IPC. In some cultures, there may be greater emphasis on collective responsibility and community health, which can influence how IPC principles are adopted and practiced.



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The structure and standards of the healthcare system, including policy enforcement around IPC, can affect how students learn and apply IPC principles. In regions with stringent IPC regulations and practices, students are likely to gain more rigorous training and adhere more strictly to IPC guidelines.

Exposure to Diverse Clinical Settings

Students in regions with diverse clinical training opportunities, including exposure to various healthcare settings and patient populations, might develop a more nuanced understanding of IPC's importance across different contexts(22).

Impact of Effective IPC Training**Impact on Patient Care and Infection Control in Healthcare Settings**

Effective IPC training has a profound impact on patient care and infection control in healthcare settings. When pharmacy students are equipped with comprehensive IPC knowledge and skills, they transition into healthcare professionals who can significantly contribute to reducing the incidence of healthcare-associated infections (HAIs). This contribution is crucial, as HAIs are a major concern globally, affecting patient outcomes, increasing hospital stay durations, and elevating healthcare costs. With a solid foundation in IPC, pharmacists can implement and advocate for stringent infection control measures, such as proper hand hygiene, appropriate use of personal protective equipment, and effective sterilization practices. Their role extends beyond personal adherence to IPC protocols; they become influencers and educators within their healthcare teams, promoting a culture of safety and compliance. Moreover, pharmacists with robust IPC training are better positioned to engage in antimicrobial stewardship, a critical aspect of infection control. They can guide the appropriate selection, dosing, and duration of antimicrobial therapy, which is pivotal in combating antimicrobial resistance. The ripple effect of effective IPC training is vast, leading to improved patient outcomes, reduced transmission of infections, and enhanced overall healthcare quality. This underscores the importance of integrating comprehensive IPC education within pharmacy curricula, ensuring that future pharmacists are well-prepared to contribute effectively to infection control efforts.

Long-term Benefits of Equipping Future Pharmacists with Robust IPC Knowledge and Practices

The long-term benefits of providing pharmacy students with robust IPC training are substantial. Firstly, it contributes to the creation of a healthcare workforce that is proficient in implementing best practices for infection prevention, thereby enhancing the overall safety and quality of healthcare delivery. In the long run, pharmacists with strong IPC knowledge can lead and participate in multidisciplinary teams to develop, implement, and evaluate infection control policies and interventions, adapting to emerging challenges such as new pathogens or resistance patterns. Educating future pharmacists in IPC also has a broader public health impact. It equips them to educate patients and the community about infection prevention, extending the benefits beyond healthcare settings into the wider community, thereby contributing to public health promotion and disease prevention. Furthermore, as healthcare continues to evolve, pharmacists with a solid foundation in IPC are better equipped to adapt to new technologies, practices, and guidelines, ensuring that their practices remain at the forefront of patient care and safety. Ultimately, investing in IPC education for pharmacy students is an investment in the future of healthcare. It ensures the sustainability of infection control efforts, contributes to the resilience of healthcare systems, and promotes a safer healthcare environment for patients and healthcare workers alike(23,24).

Recommendations for Improvement**Enhancing IPC Education in Pharmacy Schools**

To enhance IPC education in pharmacy schools, curricula should be designed to incorporate IPC topics comprehensively and pragmatically. This includes embedding IPC principles across various subjects, ensuring that students understand IPC's relevance in all aspects of pharmacy. Introducing dedicated IPC modules can provide depth, while case-based learning can illustrate IPC's application in real-world scenarios. Interactive teaching methods like simulations and role-playing can engage students actively, helping them develop practical skills in IPC.



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Incorporating digital tools and e-learning platforms can also facilitate a more flexible and accessible learning environment. Assessment strategies should evolve beyond traditional exams to include practical assessments that evaluate students' ability to apply IPC knowledge in clinical settings. This could involve simulated patient interactions or situational analysis where students propose IPC strategies for specific scenarios(25).

Policies and Initiatives to Support Improved IPC Practices

Policies should mandate the inclusion of comprehensive IPC training within pharmacy curricula, ensuring that accreditation standards reflect the importance of IPC education. Initiatives could include partnerships with healthcare institutions to provide students with hands-on IPC experience in diverse clinical settings. Encouraging inter professional education can foster a collaborative approach to IPC, reflecting the multidisciplinary nature of infection control in healthcare settings. Additionally, continuous professional development programs can ensure that students and practicing pharmacists stay updated on the latest IPC guidelines and research. Supporting research and innovation in IPC education can also drive improvements, encouraging the development of new teaching methods, materials, and assessment tools. This would not only enhance IPC practices among students but also contribute to the broader goal of improving infection control standards in healthcare(26).

Future Directions in Research and Education**Areas for Further Research in IPC KAP among Pharmacy Students**

Future research should focus on longitudinal studies to track changes in IPC KAP among pharmacy students from entry to graduation, providing insights into how education impacts long-term competencies. Investigating the correlation between IPC education and actual practice in clinical settings can highlight the effectiveness of current training methods. There's also a need for comparative studies examining IPC KAP across different pharmacy schools, identifying best practices and areas needing improvement. Research into the psychological and social factors influencing IPC adherence can offer a deeper understanding of how attitudes and behaviours are formed and changed. Additionally, exploring the impact of interprofessional education on IPC KAP can provide valuable information on how collaborative learning influences IPC outcomes(27).

Incorporating Emerging Technologies and Innovative Teaching Methods

The potential for enhancing IPC education through emerging technologies and innovative teaching methods is vast. Virtual reality (VR) and augmented reality (AR) can simulate complex clinical environments for students to practice IPC procedures in a risk-free setting. Gamification of IPC education can increase engagement and motivation, turning learning into an interactive and enjoyable experience. Artificial intelligence (AI) can offer personalized learning experiences, adapting educational content to meet individual student needs and pace. Online platforms and mobile applications can facilitate continuous learning and provide accessible resources for reinforcing IPC knowledge. Innovative teaching methods, such as flipped classrooms, can encourage active learning and critical thinking, essential for effective IPC practices. These approaches, combined with traditional education methods, can provide a more holistic and engaging learning experience, better preparing students for the IPC challenges in the healthcare environment(28).

CONCLUSION

It provides an in-depth exploration of IPC knowledge, attitudes, and practices among pharmacy students in South India, revealing critical insights into the current state of IPC education and its implications for healthcare. The review identifies significant gaps in IPC knowledge and practice, emphasizing the need for a robust and integrated approach to IPC education within pharmacy curricula. It highlights the essential role of pharmacists in infection control and patient safety, advocating for enhanced training and interdisciplinary learning to equip future pharmacists with the necessary IPC skills. The comparative analysis offers valuable perspectives on the global context of IPC education, suggesting that tailored strategies and continuous innovation are crucial for addressing regional challenges and





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aligning with international standards. The recommendations provided in the manuscript underscore the importance of policy interventions, educational reforms, and research initiatives to advance IPC practices among pharmacy students, ultimately contributing to better health outcomes and strengthening the healthcare system's response to infectious threats.

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